Estuarine fish community structure in Banten Bay Indonesia

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Abstract. Fish community structure in the aquatic environment including estuarine often affected by water quality and condition surrounding the aquatic area. Banten Bay is close to several activities that could affect water quality and its biota. This research aims to reveal the fish community structure in four estuaries in Banten Bay. Fish and water were sampled in May, July, and October 2013 in the estuarine area i.e. Wadas, Cibanten, Cengkok, and Pamong in the Banten Bay. Fishes were collected using several fishing gears which are commonly used by fishermen in each sampling station and identified in the laboratory. Four types of fishing gears were used for the sampling i.e. beach seine (Wadas), lift net (Cibanten), beach seine (Cengkok), and mullets gill net (Pamong). Several water qualities were measured and analyzed using Pollution Index methods. Trophic status was analyzed using TRIX methods. Seventeen species of fishes were collected in Wadas, twenty species in Cibanten, fifteen species in Cengkok, and one species in Pamong. Fish Diversity Index was the medium category in Wadas, Cibanten, and Cengkok estuaries while it was the low category in Pamong estuarine. Water quality that slightly polluted with the richness of nutrients supported the abundance of fishes at four estuaries in Banten Bay.

Keywords: aquatic ecology; Banten Bay; fish diversity

1. Introduction

The estuary is a transition area between river and ocean, gave effect from the interaction between land, river, and ocean, where ecologically is an ecotone between two ecosystems that happened material exchange, energy and biota. Estuarine is a kind of freshwater beside the river, lake, swamp, etc. [1]. Estuarine is a physiologic and biological transition area between land, freshwater, and ocean [2]. Vegetation and fauna in estuarine are more unique and varied than in freshwater because of several physical factors such as water movement and salinity [3].

Estuarine in the tropical area is a complex ecosystem where human activity, industrialization, and urbanization given a high impact on its ecosystem, affected water quality, quantity, and quality of plankton and other biological community [4]. Biodiversity of fish in estuarine depend on the combination from hydrological factor and biogeography [5]. The anthropogenic effect, its quality, and quantity, that entered estuarine, will be affected by fish composition in estuarine [6]. Fish community was affected by water temperature [7] and dissolved oxygen for distribution and fish biomass [8].
Banten Bay is located in Serang Regency of Banten Province with the geographic position at 05°49’45” – 06°02’00” South Latitude (SL) and 106°03’00” – 106°16’00” East Longitude (EL). Human activities on the coast of Banten Bay are very dense. There are industrial areas and Bojonegara harbor in the west, industrial areas, aquaculture area, fishing port, and fisherman housing in the south, aquaculture area, and protected forest area in the east [9]. Fishery resources are variety in Banten Bay. There are fish include demersal fish, pelagic fish, and reef fish, other resources are shellfish and seaweed [10]. According to Central Bureau of Statistics [11], several rivers empty into Banten Bay. There is Cijujung, Cibanten, Kalimati, Ciruas, Cibeureun, and Cisaat river.

According to the author's observation, estuaries in Banten Bay is the fishing area and a place of livelihood for the fisherman who lives near the estuarine. Wadas, Terate, Cibanten, Cengkok, and Pamong are several estuaries as fishing areas. Fish resources in estuarine have important economic value and easy to use for food needs and captivity for the community which lives in estuarine, even though in the small area [10]. Variety of human activity surrounding Banten Bay estuarine could be threatening fish catch since fishing as a livelihood for the fisherman who lives near the estuarine. This research aims to reveal the fish community structure in four estuarine in Banten Bay as basic data for next fisheries management.

2. Methods

2.1. Sampling methods

This research was conducted in four estuarine of Banten Bay i.e. Wadas (Station 1), Cibanten (Station 2), Cengkok (Station 3), and Pamong (Station 4) selected to represent each condition (table 1 and figure 1).

![Sampling area in Banten Bay of Indonesia.](image)
Samplings were conducted three times in May, July and October 2013. Fish and water were sampled each time of sampling. Fish was collected by followed fisherman operation in each sampling station with fishing gear that commonly used by a fisherman (table 2), then quantified and weigh length were measured. Identification is taken for five fishes for every species which previously preserved using alcohol 10% and identified according to Saanin [12], and Weber and Beaufort [13].

Water was sampled on the surface, secchi depth, and bottom of the aquatic area in each sampling station. Several water parameters measured directly using WQC (Water Quality Checker) Horiba U-10 (pH, water temperature, dissolved oxygen, and salinity). Sechi depth measured using secchi disk. Water sampled was then measured in the laboratory (nitrite, nitrate, phosphate, chlorophyll-a, Total Suspended Solids/TSS, and ammonium) according to APHA [14]. An instrument used was spectrophotometer UV-VIS Shimadzu.

**Table 1. Summary of sampling area in estuarine of Banten Bay.**

| Station | Geographic position | Information |
|---------|---------------------|-------------|
| 1       | 05°59.010’ SL  
106°06.555° EL | Wadas estuarine, close to iron industry and sugar industry. The color of the water is brownish-green with sandy mud sediment. Vegetation area dominantly with Avicennia (Avicennia marina Forssk. Vierh) |
| 2       | 06°01.334’ SL  
106°09.984’ EL | Cibanten estuarine, close to Karangantu Fishing Port, fisherman housing, and timber trading port. The color of the water is brown with mud sediment. Vegetation dominantly with mangrove tree especially Avicennia (Avicennia marina Forssk. Vierh). |
| 3       | 06°01.433’ SL  
106°10.514’ EL | Cengkok estuarine, close to aquaculture area and fisherman housing. The color of the water is brown with sandy mud sediment. Vegetation area dominantly with Avicennia (Avicennia marina Forssk. Vierh). |
| 4       | 06°00.051’ SL  
106°13.625’ EL | Pamong estuarine, close to the agriculture area and residential area. The color of the water is brownish-green. Vegetation is dominated by mangrove trees. |

**Table 2. Summary of fishing operation in estuarine of Banten Bay.**

| Station | Fishing gear | Operation methods | Operation time |
|---------|--------------|-------------------|----------------|
| 1       | Beach seine, length 100 meters, and mesh size ¾ inch | Circled the fishes and full out to the ship | 7 – 11 a.m |
| 2       | Lift net, area 12 m² and high 9 meters, and mesh size ¾ inch | Lowering the net to a certain depth then the net is lifted when enough fish are collected | 7 p.m – 5 a.m (ten hours) |
| 3       | Beach seine, length 100 meters, and mesh size ¾ inch | Circled the fishes and full out to the ship | 7 – 11 a.m |
| 4       | Mullets gill-net, mesh size ¾ inch | Fix installed in the aquatic area in four hours with ballast | 7 – 11 a.m |

2.2. Data analytical methods

2.2.1. Relative abundance of fish. The relative abundance of fish was counted according to Krebs [15] based on the presentation of each species.

\[
RB = \frac{n_i}{N} \times 100
\]  

(1)
Note:
RB : Relative abundance (%)
Ni : the amount of individual (species)
N : total number of species

2.2.2. Water quality measurement. Determination of water quality status used Pollution Index (IP) according to water quality status determination as stated at Ministry of Environment Decree number 115 in 2003 about water quality status guidelines [16]. IP value counted using the equation as follows and then evaluated to determine water quality status.

\[
PI = \sqrt{\left(\frac{Ci}{Li}\right)}^2 + \left(\frac{Ci}{Li}\right)^2 \right]/2
\]

Note:
PI : Pollution Index
Ci : Concentration of water quality parameter (i) with the unit according to parameter
Li : Water quality standard for each parameter (i) and water quality (j) with the unit according to parameter
\((Ci/Li)_{M}\) : Maximum value of Ci/Lij
\((Ci/Li)_{R}\) : Average value of Ci/Lij

Evaluation of PI value is:
0 ≤ PI ≤ 1.0 : Meet water quality standard
1.0 < PI ≤ 5.0 : Slightly polluted
5.0 < PI ≤ 10 : Moderately polluted
PI > 10 : Heavily polluted

2.2.3. Calculation of water fertility level. Calculation of water fertility level counted as Tropical Index (TRIX) using a quotation from Vollenweider et al. [17].

\[
TRIX = k \sum_{i}^{n} \frac{(\log M - \log L)}{(\log U - \log L)}
\]

Note:
K : Scaling factor
N : The amount of parameter (4) consist of orthophosphate, chlorophyll-a, oxygen saturation and nitrogen
M : Parameter value
Log U : Upper limit (average of log M+ 2Sd)
Log L : Lower limit (average of log L– 2Sd)

Criteria:
TRIX < 2 : Oligotrophic
2 ≤ TRIX < 4 : Mesotrophic
4 ≤ TRIX < 6 : Eutrophic
TRIX ≥ 6 : Hyper trophy

2.3. Fish data analysis
2.3.1. Diversity index. Diversity index using Shannon-Wiener index [18, 19] with the quotation as follows:

\[
H' = -\sum_{i=1}^{s} Pi \ln Pi \quad \text{and} \quad Pi = \frac{ni}{N}
\]
Note:

\( H' \): Diversity Index
\( \Pi_i \): Relative abundance of biota (species i) with range 0 - 1
\( n_i \): Amount of individual (species i)
\( N \): Total number of individual
\( S \): Amount of species

Criteria:

\( H' < 1 \): Low diversivity
\( 1 < H' < 3 \): Moderate diversivity
\( H' > 3 \): High diversivity

2.3.2. Domination index. Domination index is to know is there a biota that dominates the population of fish or plankton. Domination index quotation according to Simpson Domination Index [18, 19].

\[
C = \sum (\frac{n_i}{N})^2
\]  

(5)

Note:

\( C \): Simpson Domination Index (0-1)
\( n_i \): the amount of individual (species i)
\( N \): total number of individual

Criteria:

Near zero (0): no species dominate
Near 1: there are dominant species

3. Result and discussion

According to the observation, the fisherman in Station 1 and 3 use a big ship when operating their fishing gear. The fishing operation was done by three to five persons in one ship. There are approximately three to five ships in one operation hour from 7 – 11 a.m. Fishermen at Station 4 used small ships in operation. There was two schedule fishing operation in a day at Station 1, 3 and 4 except at Station 2 just one operation a day. Total fishing operation hours at stations 1, 3, and 4 were eight hours in a day. Otherwise, a fisherman at Station 2 was just one fishing operation in a day for ten hours.

The relative abundance of fishing catch at stations 1, 2, and 3 were shown in figures 2, 3, and 4. Fish caught at Station 4 was only one species, mullets (Mugil cephalus), because fishermen used fishing gear specifically to catch mullets. Relative abundance at station 4 was 100% mullets fish.

Fish caught at Station 1 consisted of 17 species from 12 families, otherwise, fish caught at Station 3 consisted of 15 species from 11 families. The fertility level at Station 1 was higher than Station 3. Station 1 and 3 used the same fishing gear namely beach seine. Fish caught was commonly similar to Station 1 and 3. There were long tongue-sole (Synaptura zebra), greek fish (Holocentrum rubrum (Forsk.), freckled goatfish (Upeneus moluccensis), common ponyfish (Leiognathus sp.), fringer scale sardinella (Sardinella Fimbriata), tripletail (Panchax panchax), mullet (Mugil cephalus) and goby fish (Brochygobius aggregatus Herre). Fish species with high relative abundance were at Station 1 and 3 namely anchovies (Stolephorus tri) and common ponyfish. According to the observation by interview to the fisherman, the habitat of the anchovies was at Station 1.

There were 20 species from 11 families caught at Station 2. Fish caught at Station 2, using lift net, mostly anchovies too, similar to Station 1 and 3. The relative abundance of anchovies in July was 30% and 34.7% in October.
Figure 2. The relative abundance of fish caught at Station 1 (in May, July, and October 2013).
The relative abundance of fish caught at Station 2 and 3 showed in figures 3 and 4.

**Figure 3.** The relative abundance of fish caught at Station 2 (in May, July, and October 2013).
**Figure 4.** The relative abundance of fish caught at Station 3 in May, July, and October 2013.
The fertility level at four stations is shown in figure 5. Fertility levels at four stations ranged from eutrophic to hypertrophic. Fertility levels ranged from 4.42–10.64. This condition could be because of the higher concentration of phosphate and chlorophyll-a concentration at four stations.

![Figure 5](image1)

**Figure 5.** Fertility level at four estuaries in Banten Bay.

Phosphate concentration was higher than the standard of seawater quality in Station 1 in May and October 2013, in Station 2 in May, July, and October 2013. Chlorophyll-a concentration in four-station ranged from 0.853–11.919 mg/m³ (figure 6 and 7).

![Figure 6](image2)

**Figure 6.** The concentration of phosphate at four estuaries in Banten Bay.
Pollution Index (PI) at four stations in Banten Banten was commonly slightly polluted (table 3). Parameters used to determine PI were salinity, Total Suspended Solids (TSS), pH, dissolved oxygen, nitrite, nitrate, ammonia, and phosphate.

Water quality at four estuaries in Banten Bay with PI value is slightly polluted and still supports the life of biota at the estuarine. Tobing [20] found that water quality in Banten Bay was still supported by bentho life. Suwandana et al. [21] found that the concentration of nutrient and heavy metal was low than the concentration of nutrient and heavy metal in Jakarta Bay. Only TSS concentration was higher than standard from Ministry of Environment Number 51 the Year 2004 about Sea Water Quality Standard [22].

Table 3. Pollution Index at Station 1, 2, 3 and 4 of Banten Bay.

| Station | Sampling Time | PI value | Water Quality Status |
|---------|--------------|----------|----------------------|
| 1       | May          | 1.15     | slightly polluted    |
|         | July         | 1.32     | slightly polluted    |
|         | October      | 0.99     | slightly polluted    |
| 2       | May          | 1.21     | slightly polluted    |
|         | July         | 1.49     | slightly polluted    |
|         | October      | 1.09     | slightly polluted    |
| 3       | May          | 0.88     | slightly polluted    |
|         | July         | 1.03     | slightly polluted    |
|         | October      | 0.79     | slightly polluted    |
| 4       | May          | 0.28     | slightly polluted    |
|         | July         | 1.15     | slightly polluted    |
|         | October      | 0.58     | slightly polluted    |

Range pH value was 7.0 – 8.5 at four estuaries in Banten Bay. Still met the requirement of the standard (figure 8).
The range of dissolved oxygen was 5.07–9.87 mg/L, which supported the equilibrium of transformation nitrogen ions between nitrite, nitrate, and ammonium ions in four estuaries (figure 9-12). Unesco in 1992 stated that dissolved oxygen in the aquatic environment should not below 2 mg/L, because if not could be caused the death of fish. The concentration of dissolved oxygen, nitrite, nitrate, and ammonia at four stations were meet the requirement of water quality standard for seawater.

Figure 8. pH value at four estuaries in Banten Bay.

Figure 9. The concentration of dissolved oxygen at four estuaries in Banten Bay.

Figure 10. The concentration of nitrite (N-NO₂) at four estuaries in Banten Bay.
Figure 11. The concentration of nitrate (N-NO₃) at four estuaries in Banten Bay.

Figure 12. The concentration of ammonia (N-NH₄) at four estuaries in Banten Bay.

The range of TSS concentration at four estuaries from three times sampling was 92.0–685.5 mg/L which was higher than standard 80 mg/L (figure 13).

Figure 13. The concentration of TSS at four estuaries in Banten Bay.
Fish caught at four estuaries in Banten Bay commonly come from the sea or having life cycles in estuaries and the sea as same as the condition at the estuary in Klabat Bay of Bangka Belitung Province [1]. Only a few species live in an estuary such as Ambassia sp. which likes shallow aquatic or estuary as benthic fish and eat insect and zooplankton (Cladocera and Copepod). Mullet (Mugil cephalus) as dominant fish species at Station 4, like to live at shallow coastal and estuary. Mullet migrate along from coastal when spawning. Mullet is a benthic fish, eat small organisms in muddy sediment or eat plankton. Fringer scale sardinella commonly lives at coastal until estuary. Like Mullet, Clupeid also a pelagic fish and feeds on plankton. Common ponyfish is a small fish that lives in shallow water until the aquatic area with a depth of 20 meters. Common ponyfish feed on zooplankton and plankton. Diversity Index and Dominance Index of fish at Station 1, 2, and 3 are shown in table 4. Dominance fish caught in every sampling time was different at three stations. The diversity index at three stations was commonly moderate.

Table 4. Diversity index and dominance index of fish at stations 1, 2, 3, and 4.

| Index          | Station 1   | Station 2   | Station 3   | Station 4   |
|---------------|-------------|-------------|-------------|-------------|
|               | May | July | Oct | May | July | Oct | May | July | Oct | May | July | Oct |
| Diversity (H')| 1.35 | 2.36 | 0.86 | 1.67 | 2.03 | 1.40 | 1.82 | 1.77 | 2.03 | 0   | 0   | 0   |
| Dominancy (C) | 0.31 | 0.11 | 0.26 | 0.31 | 0.19 | 0.29 | 0.18 | 0.19 | 0.15 | 1   | 1   | 1   |

The fertility level at four estuaries in Banten Bay supports the growth of fish because fertility level supports the growth of plankton as food for fish at stations 1, 2, 3, and 4 in Banten Bay. Species of fish caught at Station 1 and 3 that using beach seine as fishing gear were more than at Klabat Bay. Fishermen in Klabat Bay got nine species. There are groper fish, mullet, spotted scat, blind tasselfish, rayfish, giant cat-fish, ponyfish, sagor catfish, and marine catfish [1]. There are more than nine species found at Station 1 and 3 in Banten Bay using beach seine.

Fish caught at Station 1 and 3 were also more than in Klabat Bay. Fish caught from around twenty fishermen in five villages around estuarine at Klabat Bay were around 3-50 tons/year in 20 days of fishing operation [1], based on interviews with fishermen, the average catch in one day of fishing operations at station 1 and 3 in Banten Bay was around 250 kg. The number of the ship which caught fish are around five ships with five persons in one ship, so the average of the catch at Station 1 and 3 was around 300 tons/year. These results indicate that fishery production at estuarine in Banten Bay was higher than at estuarine Klabat Bay.

The second type of fishing gear operated by fishermen at Station 2 was a lift net. There were twenty species at this station. The proximity of the place to fishing activities and close to fishing ports (PPN Karangantu) is one of the reasons for using this fishing gear because using boats was more difficult given the busy sea transportation flows around the port. There were about twenty lift-net operating at each observation time in May, July, and October 2013. Species of fish caught were not much different from those caught using beach seine at Station 1 and 3, but species of fish caught with lift net are more than those with beach seine, although both are non-selective fishing tools. The most common species of fish caught using lift net was fringe scale sardinella. The production of lift net catches was around 143 kg per day, so the catch per year with an average of 20 charts operating every day is 686.4 tons/year.

The third type of fishing gear operated by fishermen at Station 4 was mullets gillnet. This gear, which is selective fishing gear, makes the catch of only one species, namely mullet. The average fish catch was 30 kg per day and two fishing boats operate per day, the fishery production at station 4 was around 14.4 tons/year. The catch at Station 4 was more than the fish caught at the estuarine in Klabat Bay which was
only 12.5 kg per day for the fishing operation [1]. According to Sugiarti et al. [23], analysis results of relationship about length and weight of mullets fish including male and female, shown growth type was negatively allometric, that length growth is more than weight growth of mullets fish.

4. Conclusion
Fishes collected were seventeen species in Wadas estuary, twenty species in Cibanten estuarine, fifteen species in Cengkok estuarine, and one species in Pamong estuaries during the study at May, July, and October 2013 in Banten Bay. Diversity Index was medium in Wadas, Cibanten, and Cengkok estuary while it was low in Pamong estuary. Water quality that slightly polluted with the richness of nutrients supported the abundance of fishes in four estuaries of Banten Bay.

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**Contributorship statement**
Sugiarti, Syahroma Husni Nasution and Sulistiono contributed equally in this research