Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 29(3) (2020) 225-239 EISSN 2543-5426

Seasonal Distribution of Benthic Foraminifera in Pangandaran Waters, Indonesia

L. P. S Yuliadi[1,*], I. Nurruhwati[2], S. Astuty[3]

[1,3]Department of Marine Science, Faculty of Fisheries and Marine Science, Padjadjaran University, Jln. Raya Bandung-Sumedang Km. 21, Jatinangor, Kab. Sumedang 45363, Indonesia

[2]Department of Fisheries, Faculty of Fisheries and Marine Science, Padjadjaran University Jln. Raya Bandung-Sumedang Km. 21, Jatinangor, Kab. Sumedang 45363, Indonesia

*E-mail address: elpeesye@gmail.com

ABSTRACT

The rapid development of tourism in Pangandaran causes various problems such as environmental degradation, environmental pollution and waste problems. Environmental changes can be detected using the foraminifera community. The reasearch aims to analyze seasonal distribution of foraminifera in Pangandaran waters. This research uses the survey method and descriptive data analysis. Ecological factors (salinity, temperature, sediment, depth, pH, DO, clarity, waves and currents) have affected their distribution. Temperature values ranged between 26 to 30 ºC. Salinity values ranged between 15.6 to 31 ‰. The pH ranged from 5.47 to 8.75. The DO concentration varied between 5.43 and 9.7 ppm. The average clarity of Pangandaran waters in the west season ranges from 56 to 104.5 cm. In Pangandaran waters, the abundance of the *Rotaliina* sub-order reaches between 75% to 86.5%, *Miliolina* 11.6% to 19%, and *Textulariina* 0.05% to 13.4%.

Keywords**:** Benthic foraminifera, ecological factor, environmental degradation, tourism, Pangandaran, pollution, waste

1. INTRODUCTION

Marine and coastal tourism is one of the fastest growing areas within the world's largest industry [5]. The socio-economic impact of coastal tourism varies and is usually very uneven in coastal communities. Besides the environmental impacts arising from the unplanned

(Received 13 January 2020; Accepted 31 January 2020; Date of Publication 01 February 2020)

development of coastal tourism result in destruction of coastal habitats [18]. Pangandaran is one of tourist destination which, located on the south coast of West Java, administratively belongs to the Ciamis district. Location of astronomical Pangandaran is 7°42'06" S and 108°29'41" E. The total area of Pangandaran Regency is 168,509 ha with an area of sea of 67,340 ha. Pangandaraan Beach is one of the most famous tourist destinations in West Java. The rapid development of tourism in Pangandaran causes various problems, such as environmental degradation, environmental pollution, and waste problems.

Foraminifera are single-celled organisms belonging to the phylum Protozoa and the majority members of foraminifera are living in the marine environment and they are particularly interesting as they have short life histories, environmentally sensitive [4]. Benthic foraminifera have different abundance, distribution patterns, and diversity dependent on the season. The distribution of benthic foraminifera appears to be primarily controlled by depth, and there is a relationship between the distribution of foraminifera and oceanographic characteristics (temperature, salinity, oxygen concentration), and nutrient concentration, substratum, chlorophyll-a concentration, and light intensity [6, 10, 13, 16]. The light factors and nutrients can also be linked because enhanced nutrient supply can result in a higher plankton productivity and further reduced light availability [20, 21].

Marine and continental habitats make them valuable as indicators of changes in the transitional areas (tidal area) [9]. Foraminifera is often used as a bio-indicator of environmental change [2]: Benthic foraminifera is sensitive and specific to its surroundings so that it can be used as a suitable indicator for environmental pollution, checking for environmental changes (such as degradation, pollution, and water and sediment contamination), responding to short- and long-term environmental changes, on a global and local scale. They have short life cycles and support specific habitats for life, they can also be used as an early warning indicator of a possible anthropic pollution.

The reasearch aims to analyze seasonal foraminiferan distribution in Pangandaran waters. The data on foraminifera assemblages are very important for better conservation on planning and environmental changes monitoring.

2. METHODOLOGY

Preparation of sample / collected sample consists of the whole seabed materials such as sediment materials and organisms, including the benthic foraminifera. This preparation is a necessity operation to separate benthic foraminifera from the other materials and organisms. This stage is held by washing, picking, description and identification, and sticking and documentation. After washing, each sample is weighed on at 100 grams and put into the labeled plastic bag.

The samples get a soaking in a 10% formaldehyde for 24 hours, then washed by water on a filter tray, and dried by oven at the temperature of 30 °C. Dried samples are put into the labeled plastic bag for an advanced analysis. After washing and filtering, the filter tray has to get a soaking in methylene blue to keep away from contaminant, and then washed. Picking up the specimens, which are suggested as the benthic foraminifera from the collected sediment, are to separate them for further analysis. The washed materials are spread out on the extraction tray under a microscope view. Recognized foraminifera are picked up and kept in a foraminiferal slide.

The picked specimens are described based on their morphology such as shell, chamber shape, chamber formation, number of chamber, ornamentation, aperture slope, aperture position, and additional chamber. Identification of the specimens is held based on references of benthic foraminifera.

This research uses the survey method and descriptive analysis to recognize the abundance. Sticking and documentation is performed to the specimens chosen which stuck to foraminiferal slide at the aperture view, dorsal view, ventral view, and side view, rather than documented under the microscope.

Physical and chemical parameter measurements are concerned with the depth measurements on each station and done using a Stick Gauge. Temperature was measured with thermometer, salinity was measured with refractometer, level of pH was determined with pH meter, dissolved oxygen (DO) concentration was determined with DO meter, and the clarity of water column was determined with a Secchi Disc. Current velocity and current direction data were obtained from https://www.copernicus.eu/ and significant wave heigth data were obtained from the Indonesian Agency for Meteorology, Climatology, and Geophysics. Observations and measurements of physical, chemical and biological parameters were carried out in the west monsoon, the first transition season, and the east monsoon.

3. RESULT AND DISCUSSION

3. 1. Physical and chemical parameters of Pangandaran Waters

Water quality varies both spatially and temporally. Monitoring of water quality aims to assess water concerning of both, physical, chemical, and biological parameters and to assess the feasibility of a water resource for certain purposes. It has been recognized that the quality of receiving waters is affected by human activities in a watershed via point sources, such as wastewater treatment facilities, and non-point sources, such as runoff from urban area [21].

The results of the physical-chemical parameters of the waters of Pangandaran Waters are presented in Table 1:

Table 1. The Physical-Chemical Parameters of Pangandaran Waters.

Station	Longitude	Latitude	Salinity (ppt)	DO (ppm)	pH	Temperature (°C)	Clarity (cm)	Depth (cm)
West Monsoon								
1	108º39'58.1"E	7º42'22,4"S	28.3	6.3	8.06	28	56.5	90
2	108º39'44.9"E	7º42'17,9"S	27.3	7.06	8.06	28.3	91	120
3	108 º 39'38.8"E	7 º 41'49.8"S	15.6	5.96	8.07	29	94	358
4	108º39'36.9"E	7º41'56.7"S	20	5.63	8.07	30	100	110
5	108º40'24.7"E	7º41'05.5"S	18.6	5.53	8.07	30	94	480

First Transitional Season								
1	108°39'32.33"E	7°42'09.18"S	23	9.7	5.48	26	57	90
2	108°39'32.47"E	7°42'10.57"S	23	9.7	5.47	27	90	120
3	108°38'46.98"E	7°41'32.94"S	24	8	5.8	27	94	356
4	108°38'40.84"E	7°41'29.62"S	23	8.5	5.50	27	98	109
5	108°38'33.04"E	7°41'24.22"S	24	9.5	5.51	27	92	380
East Monsoon								
1	108 º39'44.80"E	7º41'37.64"S	29.7	5.97	8.75	29	94	230
2	108 º40'76.97" E	7º41'17.39"S	29.3	5.87	8.64	29.7	68,5	82
3	108 º38'26.41" E	7º41'24.75"S	28	5.67	8.53	30	58	145
4	108 º37'35.32" E	7º41'18.40"S	28.6	5.53	8.51	30	94	153
5	108 º37'43.24" E	7º41'11.06"S	31	5.43	8.26	30	104,5	120

The observed temperature values ranged between 28 to 30 ºC in west monsoon, 26 to 27 ºC in the first transitional season, and 29 to 30 ºC in east monsoon. The surface water temperature has been influenced by intensity of solar radiation, evaporation, and flow from adjoining neritic waters. The surface water temperature varied from 26 to 30 ºC, mainly with changes in monthly variation. Higher surface water temperature recorded during the east monsoon might be due to the increased solar radiation intensity.

The observed salinity values ranged between 15.6 to 31 ‰. The minimum salinity was obtained in the first transitional season at the station 3 and the maximum salinity was registered in east monsoon at the station 5 (Table 1). Most of the benthic foraminifera are stenohaline, have a low tolerance to changes in salinity, but some species are euryhaline, and have a wide tolerance to changes in the salinity and life in the marine environment near a large salinity range. It can be seen in the estuary of the river [15].

The pH ranged from 8.06 to 8.07 in west monsoon, 5.47 to 5.8 in the first transitional season, 8.26 to 8.75 in east monsoon. Fluctuations in pH values during different seasons of the year can be attributed to the factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of the salinity and temperature, and decomposition of organic matter. The DO concentration varied between 5.43 and 9.7 ppm, registering maximum 9.7 ppm (station 1 and 2) in the transitional season and minimum 5.43 (station 5) in east monsoon. The DO concentration in waters reach very low levels in east monsoon due to the high temperatures and evaporation.

Water clarity depends on color and turbidity. Clarity is a measure of water transparency that is determined visually. The clarity value is expressed in meters. This value is strongly influenced by weather conditions, measurement time, turbidity and suspended solids.

The average clarity of Pangandaran waters in the west season ranges from 56 to 100 cm, in the first transitional season ranges from 57 to 98 cm and in the east season ranges from 58 to 104.5 cm. Temperature is always inversely correlated with salinity and water transparency. Transparency decreased more during the wet season than during the dry season due to flooding from adjacent catchment areas [19].

Current motion can spread the suspended solid to waters. Clarity is largely determined by the dissolved particles and mud. Turbidity or suspended material concentration in the waters will reduce the feeding efficiency of the organism.

3. 2. The surface current pattern

Indonesian waters have a surface flow pattern that is strongly influenced by the west monsoon (December to March) and east monsoon (June to September). The influence of these two monsoons is clearly seen on the South Coast of Java. In the west monsoon the surface currents in the South Java Sea move from the west to east or towards the east, in the east monsoon the currents move from the east to west. The pattern of monthly average current movement is generated by tides and winds, where the more dominant is the influence of wind movement.

West monsoon (December to March) occurs when the wind blows from the west to east. Offshore Current movements are directed to the west due to the South Equatorial Current, while near the coast or about 50 km from the coastline there are currents along the coast moving eastward, which are known as the South Java Current. The first transition season (April to May) occurs with the wind transition from the east to west. The current direction heading west is quite small due to the relatively small wind strength. East Monsoon (June to September) occurs when the wind blows from the east to west. Current movements are generally directed from the east to west. In this season, the South Java current is strengthened by the presence of monsoon winds so that the speed is maximum.

Surface current velocity in the west monsoon ranges from 0.16 - 0.26 m/s, the dominant direction from east to west. Surface current velocity in the first transitional season ranges from 0.25 - 0.33 m/s, the dominant direction from the soutwest to norteast. Surface current velocity in the east monsoon ranges from 0.36 - 0.6 m/s, the dominant direction from the nortwest to southeast (Figure 1).

3. 3. Waves condition

Sea waves are the dominant physical factor in the South West Java waters, because most of these waters has high wave heights in offshore waters, which are between 2 to 5 m. Wind wave height is basically relatively small for the coastal areas, especially in the bay waters, ranging from 95 to 105 cm (Figure 2).

However, for the open sea with the form of a narrow exposure zone that is widely available in a number of locations, it is very possible the occurrence of violent waves to the coast. Waves break near the shore with a high wave height so that the energy reaching the shore is still relatively strong.

The direction of the surface current comes from the east to the west, at an average speed of 1 m/s. Waves and currents play an important role in the distribution of nutrients and food sources for foraminifera. Local transportation of foraminifera is caused by waves, and the waves caused by currents [3, 7, 12].

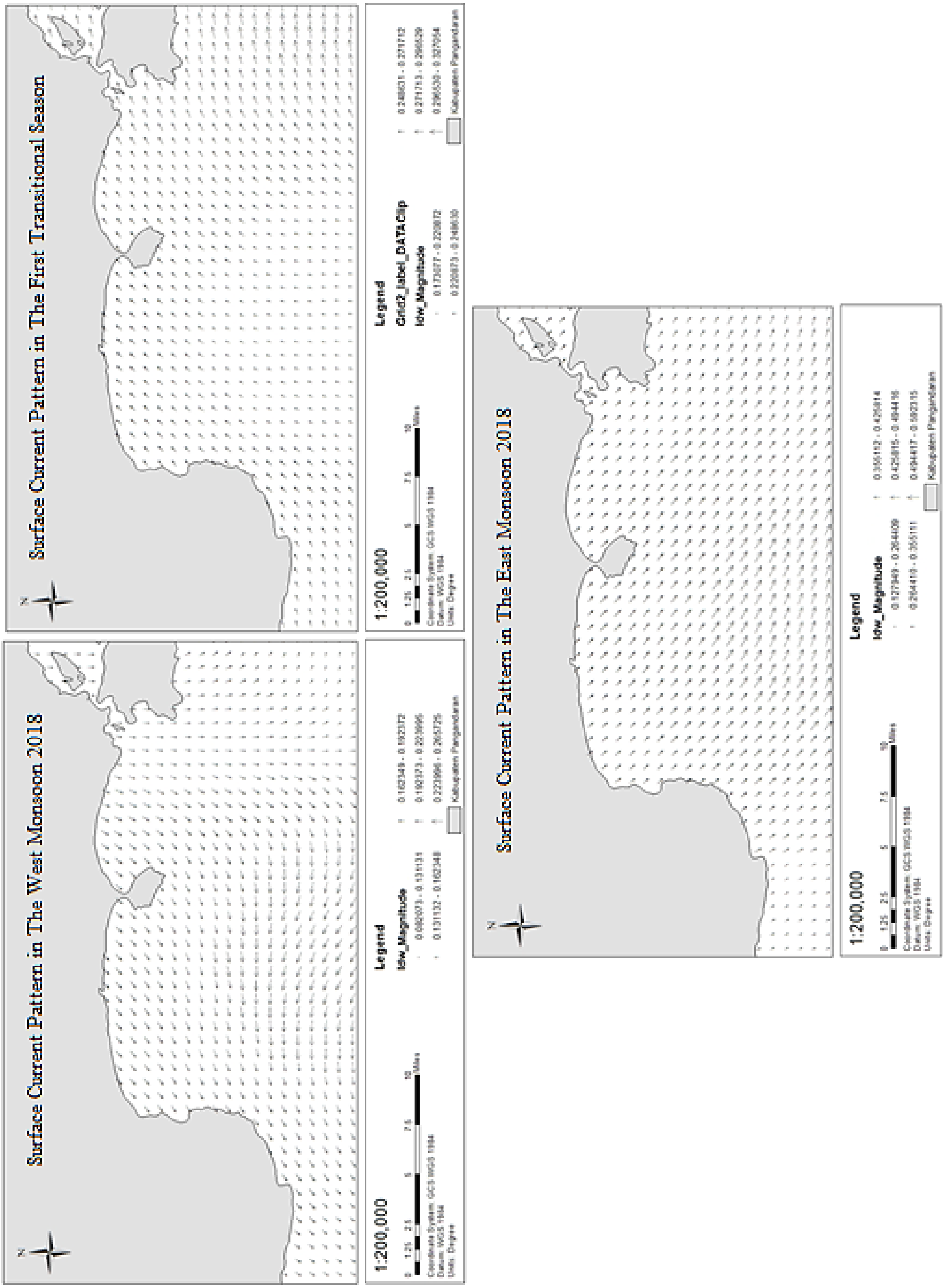


Figure 1. Surface current pattern in Pangandaran Waters, 2018

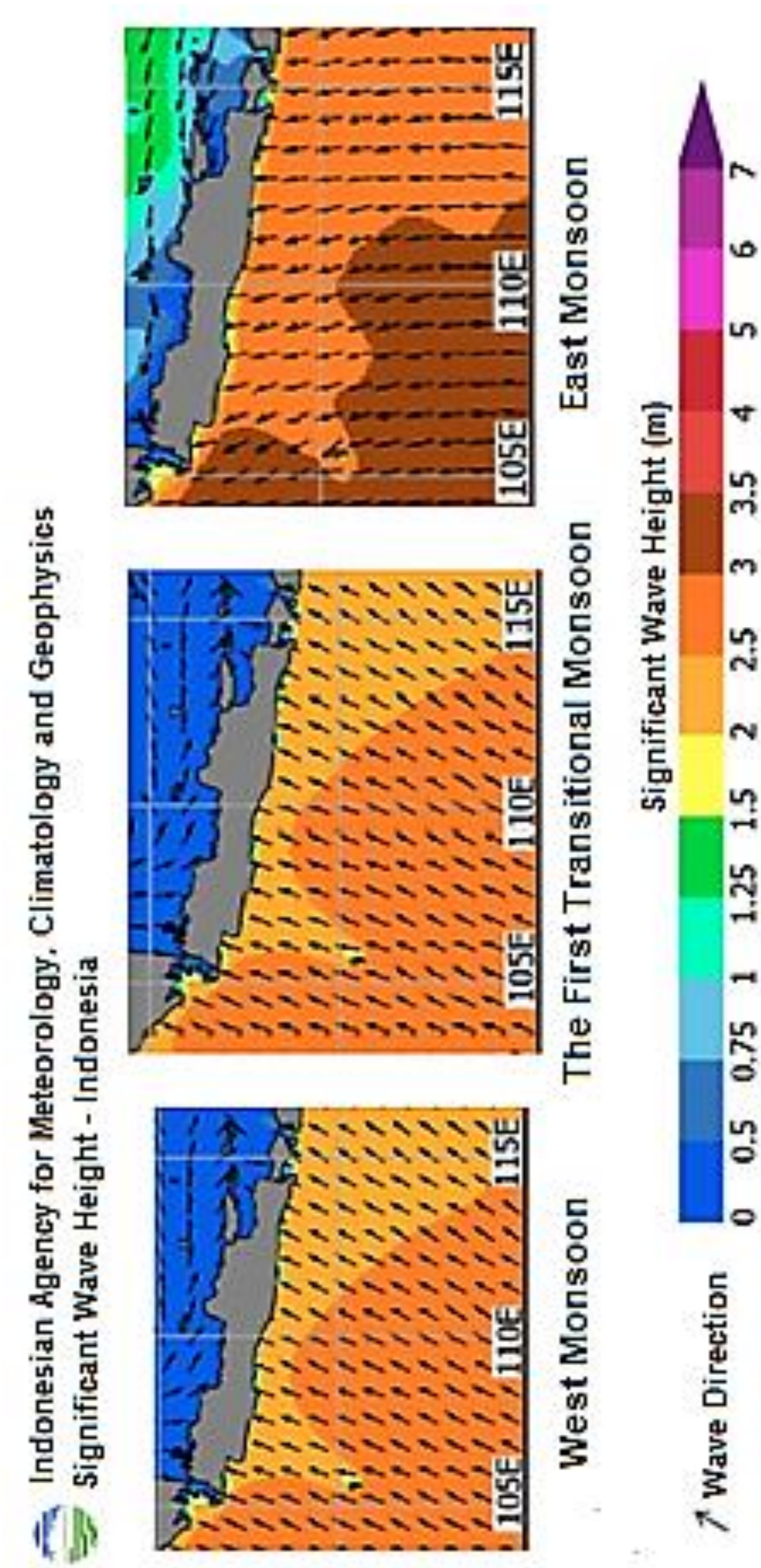


Figure 2. The wave heigth of Pangandaran Waters

3. 4. Sediment grains size

The results of the sediment grain size analysis concluded in the form of the proportion of each sub-population of the size class. In general, the surface sediment in the study area is composed by Muddy sand, Sandy gravel, Gravelly sand, Sand, and Silty sand.

The pattern of surface sediment distribution is influenced by the characteristics of oceanography and sediment type of Pangandaran Waters. The results of the sediment grain size analysis is given in Table 2.

Table 2. The Sediment Grain Size Analysis.

Season	Station	Sediment Classification
West monsoon	1	Muddy sand
	2	Muddy sand
	3	Sandy gravel
	4	Sandy gravel
	5	Muddy sand
First Transitional Season	1	Gravelly sand
	2	Muddy sand
	3	Sand
	4	Gravelly sand
	5	Gravelly sand
East Monsoon	1	Silty sand
	2	Gravelly sand
	3	Silty sand
	4	Gravelly sand
	5	Silty sand

The size of sand will settle not far from the source that is in the area around the mouth of the river, on the contrary, further away from the mouth of the river, the proportion of the deposited sand is less, and in this area (towards the sea) the sediment is dominated by clay and silt. Mud and silt substrate is an ideal place for foraminifera. Some species of the benthic foraminifera are often found in sandy and muddy sediments [17].

3. 5. Benthic foraminifera in Pangandaran Waters

Genera of the benthic foraminifera found abundantly in the western season are as follows: *Calcarina*, *Pararotalia* and *Streblus* (Rotaliina sub-order), *Quinqueloculina* (Miliolina sub-order), *Textularia* (Sub-order Textulariina). Genera of the benthic foraminifera found abundantly in the transitional season are: *Ammonia*, *Pararotalia*, *Pseudorotalia* (sub-order Rotaliina), *Quinqueloculina* (sub-order Miliolina). Genera of the benthic foraminifera found abundantly in the eastern monsoon are: *Streblus* (sub-order Rotaliina), *Quinqueloculina* (Sub-order Miliolina). Most of benthic foraminifera collected from the study area were indicators for shallow marine environment such as *Amphistegina*, *Quinqueloculina*, *Operculina*, *Pseudorotalia*, and *Elphidium* [15].

The types of foraminifera associated with reefs include: *Acervulina inhaerens*, *Ammonia beccarii*, *Amphistegina lessonii*, *Archaias angulatus*, *Clavulina tricarinata*, *Cibicides refulgens*, *Elphidium advenum*, and *Elphidium sagrum* [8]. Some foraminifera commonly found on the Great Barrier Reef with the symbiosis with algae, among others are: *Alveolinella*, *Amphistegina*, *Calcarina*, *Heterostegina*, *Marginopera*, *Peneroplis*, and *Sorites*, whereas *Ammonia*, *Bolivina*, *Elphidium*, *Pseudorotalia*, *Streblus*, *Pararotalia*, and *Uvigerina* are the opportunistic types. These opportunistic types are usually found in abundance in the environments where one of the parameters is already abnormal due to a disturbance either naturally or due to anthropogenic factors [20, 21]. The presence, abundance, diversity and distribution of aquatic species in surface waters are dependent upon of physical and chemical factors, such as temperature, suspended solids, pH, and nutrients [22].

Table 3. Benthic foraminifera in Pangandaran Waters.

Sub Order/ Genus	West Monsoon					The First Transitional Season					East Monsoon				
	Station					Station					Station				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Rotaliina															
Ammonia	15	1	13	0	0	5	66	260	26	13	0	0	0	0	0
Amphistegina	7	27	1	0	13	0	0	7	5	2	28	6	24	1	1
Anomalinella	0	0	0	0	9	1	0	5	3	0	0	2	40	2	0
Anomalinoides	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0
Asterorotalia	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0
Bolivinita	0	0	0	0	0	0	1	0	0	0	2	2	0	1	0
Bulimina	7	5	0	0	0	0	0	0	0	0	0	0	0	1	4
Calcarina	25	10	134	159	29	0	0	0	0	0	0	14	0	0	0
Cancris	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0

Sub Order/ Genus	**West Monsoon**					**The First Transitional Season**					**East Monsoon**				
	Station					**Station**					**Station**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Cibicides	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0
Ehrenbergina	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium	15	15	14	9	19	1	7	6	1	1	2	12	56	0	4
Epinodes	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Fontbotia	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Gyroidina	1	1	0	0	0	0	0	0	0	0	4	0	0	0	1
Hanzawaia	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
Heterolepa	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0

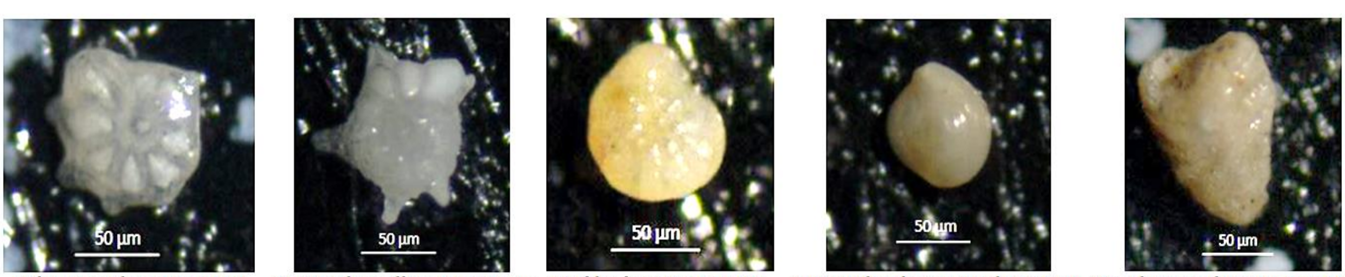
Sub Order/ Genus	**West Monsoon**					**The First Transitional Season**					**East Monsoon**				
	Station					**Station**					**Station**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Hyalinea	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Lagena	4	1	0	0	4	0	0	0	0	0	0	0	0	0	0
Lenticulina	17	14	0	0	5	4	0	0	0	0	0	0	0	0	0
Melonis	0	0	0	0	3	2	0	0	0	0	0	0	8	0	0
Neorotalia	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Nodosaria	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Neouvigerina	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Nonion	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0
Operculina	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pararotalia	4	3	79	57	37	10	42	29	15	16	0	0	0	0	3
Planulina	4	6	0	0	8	0	3	1	7	4	4	4	16	0	6
Pseudorotalia	0	0	0	0	0	9	91	2	0	0	0	0	0	0	0
Quadrimorphina	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Rectobolivina	2	2	0	0	2	0	0	0	1	0	0	0	0	2	2
Reussella	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Sub Order/ Genus	**West Monsoon**					**The First Transitional Season**					**East Monsoon**				
	Station					**Station**					**Station**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Rutherfordoides	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagrinella	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeroidina	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Stomatorbina	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Streblus	53	48	1	20	58	9	0	0	0	0	98	278	808	58	47
Trochulina dimidiata	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
Uvigerina	4	1	0	0	0	0	0	0	0	0	2	0	0	0	1
Valvulineria	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Miliolina															
Adelosina	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Cycloforina	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Dentalina	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lachlanella	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Milionella	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Milliolinella	0	0	0	0	6	0	0	0	0	0	0	6	0	0	0
Pyrgo	1	1	0	2	0	0	0	0	0	0	0	0	0	2	0
Quinqueloculina	17	29	0	12	67	0	7	85	7	6	20	56	224	6	15
Schlumbergerina	0	0	0	0	1	0	0	0	0	0	2	0	8	0	0
Sigmoilina	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Spirosigmoilina	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0
Triloculina	0	0	0	0	2	0	0	0	0	0	2	0	24	0	0
Sub Order/ Genus	**West Monsoon**					**The First Transitional Season**					**East Monsoon**				
	Station					**Station**					**Station**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Textulariina															
Bigenerina	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0

Sub Order/ Genus	**West Monsoon**					**The First Transitional Season**					**East Monsoon**				
	Station					**Station**					**Station**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gaudryina	9	12	0	10	1	0	0	0	0	0	0	0	0	0	0
Gaydryinella	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Martinottiella	5	0	0	1	7	0	0	0	0	0	0	0	0	0	0
Migros	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Reophax	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Siphotextularia	3	1	0	0	6	0	0	0	0	0	0	0	0	0	0
Textularia	30	39	7	23	15	0	0	2	0	0	0	0	0	1	0
Trochammina	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0

The spread of the benthic foraminifera organisms is influenced by oceanographic characteristics, including physical and chemical parameters of aquatic. *Elphidium* is usually found in turbid waters at high nutrient concentration content [17]. Life and distribution of the benthic foraminifera depend on the abiotic and biotic factors of the transition environment, such as salinity, temperature, substrate, depth, nutrition, sediments, turbidity, waves and currents, and other ecological factors. Between the benthic foraminifera and coral reef, a mutualistic symbiosis occurs. Foraminifera is a very abundant habitat in a coral reef environment, to produce biogenic material as a building material to obtain corals [22].

The number of benthic foraminiferal tests and the distribution of several nearshore species are influenced by the outflow of the estuary and by local hydrodynamic conditions. The deeper water assemblages were found to be more related to low levels of tidal energy, low oxygen environments are associated with fine-grained sediments, and cold-water filaments related to seasonal upwelling [11]. Spesies of foraminifera were found abundantly in Pangandaran Waters (Figure 3).



Calcarina calcar **d'Orbigny** *Pararotalia stellata* **de Ferussac** *Streblus becarii* **Linnaeus** *Quinqueloculina seminulum* **Linne** *Textularia agglutinans* **d'Orbigny**

Figure 3. Benthic Foraminifera in Pangandaran Waters

The distribution pattern of benthic foraminifera in Pangandaran waters in the west season, first transition, and the eastern season 2018 can be seen in the following Figure 4. The abundance of the *Rotaliina* sub-order is 75%, *Miliolina* 11.6%, and *Textulariina* 13.4%, in the west monsoon. The abundance of the *Rotaliina* sub-order is 80.95%, *Miliolina* 19%, and *Textulariina* 0.05% in the first transitional season. The abundance of the *Rotaliina* sub-order is 86.5%, *Miliolina* 13.25%, and *Textulariina* 0.25%, in the east monsoon. *Rotaliina* is the most abundant benthic foraminifera sub-order compared to the others.

This shows that the Pangandaran waters support the abundance of *Rotaliina* (hyalline). It appears, the *Rotaliina* sub-order dominates at every station and in every season. Sub-order *Textulariina* is a benthic foraminifera organism with agglutinin shell. The lack of variation in the *Textulariina* sub-order at the study site is due to the data collection carried out in shallow waters. The abundance of the *Textulariina* sub-order in waters characterizes the open water environment and includes deep waters.

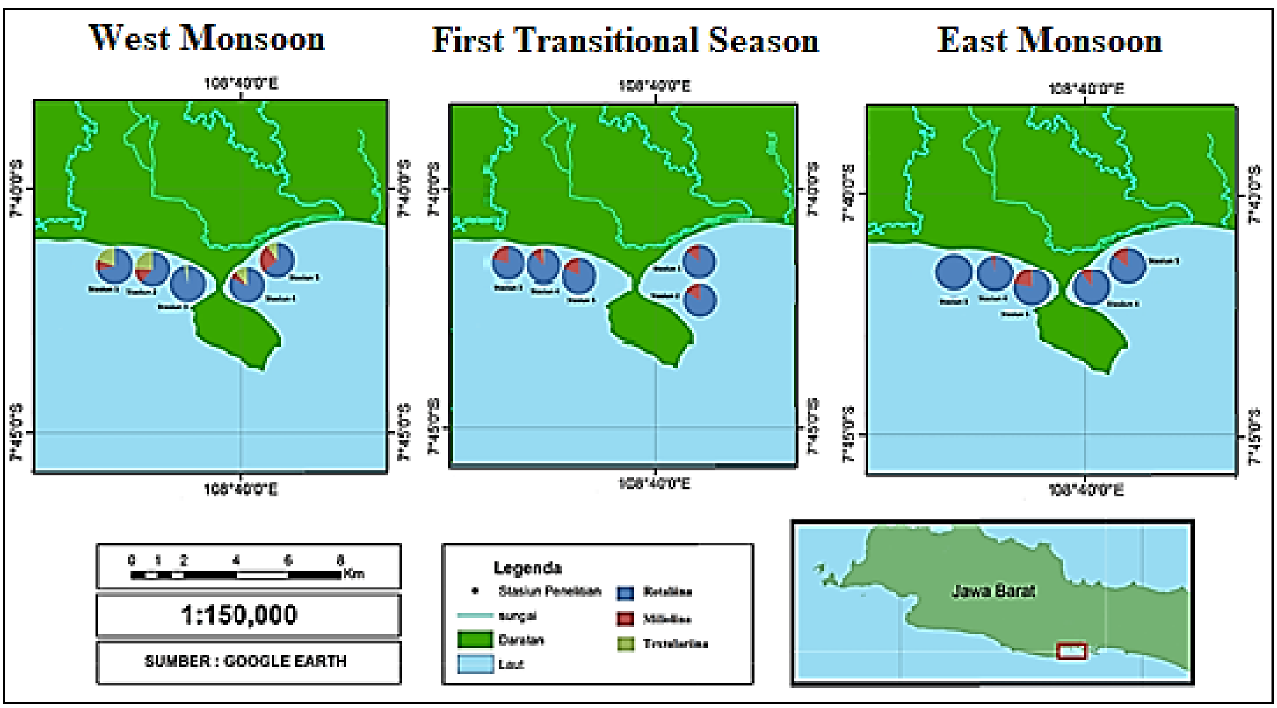


Figure 4. Distribution of Benthic Foraminifera in Pangandaran Waters (in 2018)

Seasonality is not to be a controlling factor for the distribution of individual abundances. The generally high dominance of individuals in the surface is probably related to the presence of microalgal food there, thus the number of species recorded varied from one season to another. Seasonal changes occur in the distribution of foraminifera [1]. Consistent absence of the seasonal patterns for each station indicates that seasonality is not a controlling factor for individual distribution. The restricted connectivity between estuary and open sea has a direct influence on the variations of environmental variables, and consequently, on the foraminiferal abundance and its spatial distribution [14].

4. CONCLUSIONS

It was noticed, the ecological factors (salinity, temperature, sediment, depth, pH, DO, clarity, waves and currents) have affected their distribution. The abundance of the *Rotaliina* sub-order reaches between 75% to 86.5%, *Miliolina* 11.6% to 19%, and *Textulariina* 0.05% to 13.4% in the Pangandaran waters.

The decline in water quality occurs due to the pollution in coastal areas. Pollution of solid waste and waste (marine debris) causes a disturbance and decrease the marine biota population. Wastes from along the watershed are traversed, especially passing through residential or industrial areas. Efforts are needed to save coastal and marine areas: integrating coastal area planning with land, especially watersheds, increasing law enforcement efforts for violations, conducting economic activities that are environmentally friendly, and raising public awareness through environmental education activities.

Acknowledgement

This research was supported by the Ministry of Research, Technology and Higher Education of The Republic of Indonesia, Directorate for Research, Community Service and Innovation (DRPMI) Padjadjaran University, Tourism and Culture Office of Pangandaran, Dean of Faculty Fisheries and Marine Science Padjadjaran University, Research Team HIU 2018.

References

[1] Alve, E., & Murray, J. W. Temporal variability in vertical distributions of live (stained) intertidal foraminifera, southern England. *The Journal of Foraminiferal Research* 31(1) (2001) 12-24

[2] AM, Muhamad N. The distribution of benthic foraminifera on selected marine sediments in pahang river estuary, Pahang, Malaysia: Identification using sem images. *Malaysian Journal of Microscopy* 10(1) (2014) 41-46

[3] Briguglio, A., & Hohenegger, J. How to react to shallow water hydrodynamics: the larger benthic foraminifera solution. *Marine Micropaleontology* 81(1-2) (2011) 63-76

[4] Dias, B.B., Hart, M.B., Smart, C.W., & Hall-Spencer, J. M. Modern seawater acidification: the response of foraminifera to high-CO2 conditions in the Mediterranean Sea. *Journal of the Geological Society* 167(5) (2010) 843-846

[5] Hall, C.M. Trends in ocean and coastal tourism: the end of the last frontier? *Ocean & Coastal Management* 44(9-10) (2001) 601-618

[6] Hohenegger, J. Depth coenoclines and environmental considerations of western Pacific larger foraminifera. *The Journal of Foraminiferal Research* 34(1) (2004) 9-33.

[7] Hohenegger, J. The importance of symbiont-bearing benthic foraminifera for West Pacific carbonate beach environments. *Marine Micropaleontology* 61(1-3) (2006) 4-39

[8] Javaux, E.J., & Scott, D.B. Illustration of modern benthic foraminifera from Bermuda and remarks on distribution in other subtropical/tropical areas. *Palaeontologia Electronica* 6(4) (2003) 29

[9] Jorissen, F. J. Benthic foraminiferal successions across Late Quaternary Mediterranean sapropels. *Marine Geology* 153(1-4) (1999) 91-101

[10] Kuroyanagi, A., & Kawahata, H. Vertical distribution of living planktonic foraminifera in the seas around Japan. *Marine Micropaleontology* 53(1-2) (2004) 173-196

[11] Mendes, I., Gonzalez, R., Dias, J.M.A., Lobo, F., & Martins, V. Factors influencing recent benthic foraminifera distribution on the Guadiana shelf (Southwestern Iberia). *Marine Micropaleontology* 51(1-2) (2004) 171-192

[12] Murray, J.W., & Alve, E. Natural dissolution of modern shallow water benthic foraminifera: taphonomic effects on the palaeoecological record. *Palaeogeography, Palaeoclimatology, Palaeoecology* 146(1-4) (1999) 195-209

[13] Murgese, D.S., & De Deckker, P. The distribution of deep-sea benthic foraminifera in core tops from the eastern Indian Ocean. *Marine Micropaleontology* 56(1-2) (2005) 25-49

[14] Nagendra, R., Sathiyamoorthy, P., Reddy, A.N., & Ramachandran, A. Spatial distribution of benthic foraminifera in the Palar estuary, Tamil Nadu. *Journal of the Geological Society of India* 86(3) (2015) 305-316

[15] Natsir, S.M., & Subkhan, M. The distribution of benthic foraminifera in coral reefs community and seagrass bad of Belitung Islands based on FORAM Index. *Journal of Coastal Development* 15(1) (2011) 51-58

[16] Renema, W. Habitat variables determining the occurrence of large benthic foraminifera in the Berau area (East Kalimantan, Indonesia). *Coral Reefs* 25(3) (2006) 351-359

[17] Renema, W. Habitat selective factors influencing the distribution of larger benthic foraminiferal assemblages over the Kepulauan Seribu. *Marine Micropaleontology* 68(3-4) (2008) 286-298

[18] Scott, D., Simpson, M. C., & Sim, R. The vulnerability of Caribbean coastal tourism to scenarios of climate change related sea level rise. *Journal of Sustainable Tourism* 20(6) (2012) 883-898

[19] Simier, M., Laurent, C., Ecoutin, J. M., & Albaret, J. J. The Gambia River estuary: A reference point for estuarine fish assemblages studies in West Africa. *Estuarine, Coastal and Shelf Science* 69(3-4) (2006) 615-628

[20] Srinjana Ghosh, Rupendu Ray, Suchandra Chowdhury. Abundance and diversity profile of invertebrate macro benthic faunal components in a coastal ecosystem of Eastern India. *World Scientific News* 102 (2018) 59-75

[21] Uthicke, S., & Nobes, K. Benthic foraminifera as indicators for terrestrial runnoff: A foram index for the GBR. *Estuarine, Coastal and Shelf Science* 78 (2008) 763-773

[22] Wang, X. Integrating water-quality management and land-use planning in a watershed context. *Journal of Environmental Management* 61(1) (2001) 25-36