OSEANOLOGI DAN LIMNOLOGI DI INDONESIA
Print ISSN: 0125-9830 Online ISSN: 2477-328X
Nomor Akreditasi: 712/AU3/P2MI – LIPI/10/2015
http://jurnal-oldi.or.id

Molluscs Diversity in Coastal Ecosystem of South Biak, Papua

Keanekaragaman Moluska di Ekosistem Pesisir Biak Selatan, Papua

Ludi Parwadani Aji and Andriani Widyastuti

Technical Implementation Unit for Biak Marine Life Conservation, RC for Oceanography LIPI

Email: ludi_bio@yahoo.co.id

Submitted 17 May 2016. Reviewed 14 November 2016. Accepted 5 December 2016.

Abstract

Coastal areas of Biak Island consist of three major ecosystems: the mangrove, seagrass beds, and coral reefs where a variety of molluscs live. Mollusc diversity in South Biak waters was investigated in September 2011. The observation was conducted at 4 locations, i.e. Paray, Ambroben, Yenures, and Sorido with 2 stations at each location. The study aimed to obtain information on the diversity and community structure of the benthic molluscs (gastropods and bivalves) on the coastal areas of South Biak waters. Sampling method applied was quadrate-transect line in intertidal areas from inshore to offshore. The molluscs (epifauna and infauna) found inside the quadrate-transect were counted and identified. The result showed high benthic mollusc diversity with a total of 94 species, consisting of 75 species of gastropods and 19 species of bivalves. The most widespread gastropod found in all stations was *Nassarius* sp., while for bivalves was *Tellina* sp. The highest value of diversity index (H) was 2.96 found in Paray 1 and the lowest was 0.58 in Yenures 1. The Evenness index (E) and Simpson index (D) ranged from 0.27 to 0.96 and from 0.06 to 0.72 respectively. Species richness (d) ranged from 2.89 to 6.84 and similarity index from 3.90 to 42.40.

Keywords: Molluscs, gastropods, bivalves, diversity, South Biak.

Abstrak

Daerah pesisir Pulau Biak terdiri dari tiga ekosistem utama, yaitu hutan bakau, padang lamun, dan terumbu karang tempat hidup berbagai jenis moluska. Tujuan penelitian ini adalah untuk mendapatkan informasi mengenai keanekaragaman dan struktur komunitas moluska bentik (gastropoda dan bivalvia) di daerah pesisir perairan Biak. Keanekaragaman moluska di perairan Biak Selatan diteliti pada bulan September 2011. Penelitian dilaksanakan di 4 lokasi, yaitu Paray, Ambroben, Yenures, dan Sorido dengan setiap lokasi terdiri dari 2 stasiun. Metode sampling yang digunakan adalah transek garis kuadrat mulai dari daerah pasang surut dari pantai menuju laut. Moluska epifauna dan infauna yang didapatkan di dalam transek dihitung dan diidentifikasi. Hasil penelitian menunjukkan bahwa keanekaragaman moluska bentik cukup tinggi karena ditemukan 94 spesies yang terdiri dari 75 gastropoda dan 19 bivalvia. Gastropoda dengan persebaran tertinggi yang ditemukan di semua stasiun adalah *Nassarius* sp., sedangkan pada bivalvia adalah *Tellina* sp. Nilai tertinggi indeks keanekaragaman jenis (H) adalah 2,96 yang didapatkan di perairan Paray 1 dan terendah adalah 0,58 di perairan Yenures 1. Indeks kemerataan (E) dan indeks dominansi (D) berkisar

0,27–0,96 dan 0,06–0,72. Indeks kekayaan jenis (d) berkisar 2,89–6,84 dan indeks kesamaan berkisar 3,90–42,40.

Kata kunci: Moluska, gastropoda, bivalvia, keanekaragaman, Biak Selatan.

Introduction

Molluscs represent the largest phyla in the marine environment and are ecologically and economically important (Poppe et al. 2014). The number of species identified under the phylum Mollusca reaches more than 50,000. Gastropods and bivalves constitute most of the total population of molluscs in which most of them inhabit marine environments (Hickman et al. 2004). Molluscs are particularly useful as a biodiversity indicator for ecosystems adjacent to the reefs (e.g. sand, mud, rubble bottoms, and seagrass beds) where corals are generally absent or rare (Urra et al. 2013). Therefore, the existence of molluscs in an aquatic ecosystem can be used as an indicator to determine the environmental water quality.

Mollusc diversity recorded in the survey of “The Coral Triangle” area (the world richest area for coral reefs encompassing North Australia, Indonesia, The Philippines, and Papua New Guinea) conducted by the Conservation International and the Western Australian Museum showed a high diversity (Wells 2002). There were 665 mollusc species found in Raja Ampat Islands, Indonesia (Wells 2002) and 651 species in Calamianes Group, The Philippines (Wells 2000). Wells (1998) also provided a detailed report on the molluscs of the Milne Bay, Papua, where 638 species were recorded.

Coastal ecosystem provides the basis of food web, the nursery grounds and the habitat for many marine organisms, some of which play important roles in local fisheries. The worldwide ecosystem of coastal areas is declining, due to the development and high density of human populations near the coasts that resulted in unsustainable levels of pressure. Human activities have caused serious coral reef degradation mostly through destructive fishing, pollution, and overfishing. The impact does not depend only on the exploitation pressure, but also on the vulnerability of the species regarding exploitation (van der Meij et al. 2009). Marine molluscs are vulnerable to overfishing because they are easy to catch by shore gleaning, reef-walking, snorkeling, or diving.

Biak is a small island located in Cendrawasih Bay near the northern coast of West Papua, Indonesia. Biak traditional fishery targets a wide range of exploitable resources in intertidal areas such as molluscs that provide a key source of income and food for Biak people. Current demographic pressures in Biak are resulting in greater exploitation of marine molluscs (Widyastuti et al. 2013). The molluscs (gastropods and bivalves) living in the shoreline of coastal areas are collected mostly by women and children during low tide periods. The resource potential of coastal waters of South Biak are numerous and the increasing community activities either directly or indirectly will influence the environmental quality of the waters in South Biak. This will also affect the diversity and community structure of benthic organisms as reported by Aji et al. (2015) that the abundance of megabenthos which has economic values recorded in year 2014 to 2015 in the coral reef ecosystem has decreased.

This research is to gain insight into the diversity and community structure of gastropods and bivalves in the coastal waters of South Biak linked to human activities such as fishing. Moreover, this study is expected to provide information about the diversity of gastropods and bivalves in order to promote the marine conservation and the use of sustainable marine resources.

Methodology

Sampling was conducted in South Biak, Biak Island, Papua (Figure 1) in September 2011 at 4 locations, each with 2 stations. The 8 stations were Paray1 (Station 1), Paray2 (Station 2), Ambroben1 (Station 3), Ambroben2 (Station 4), Yenures1 (Station 5), Yenures2 (Station 6), Sorido1 (Station 7), and Sorido2 (Station 8). Sampling locations chosen represented the human activity such as fishing area. Paray is a marine conservation area that lacks of fishing activity. Ambroben and Sorido have medium human activity in which some fishermen are doing their fishing activity, while Yenures has high human activity as it is adjacent to residential areas.

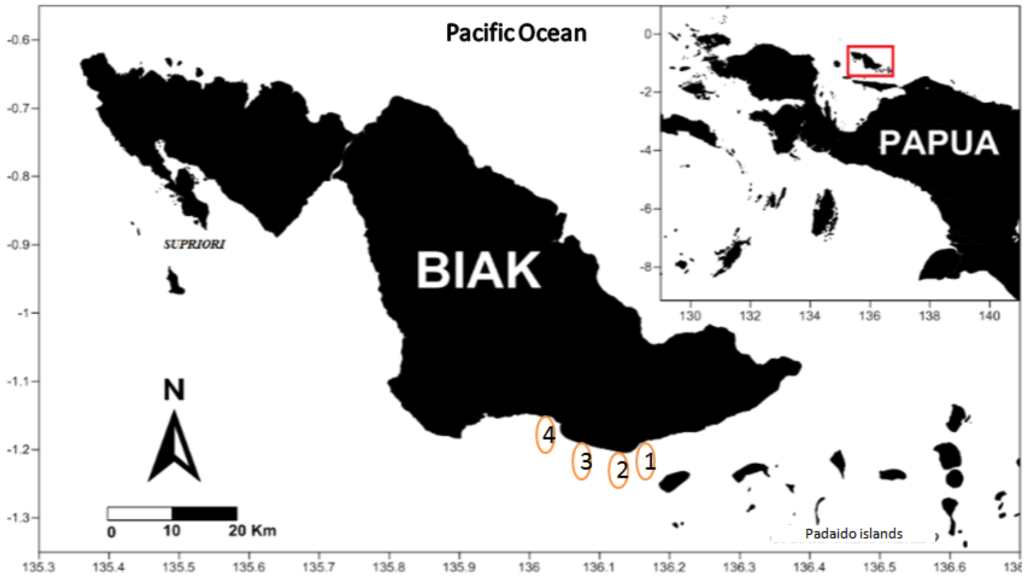


Figure 1. Sampling locations in South Biak, Papua (1: Paray, 2: Ambroben, 3: Yenures, 4: Sorido).
Gambar 1. Lokasi sampling di Biak Selatan, Papua (1: Paray, 2: Ambroben, 3: Yenures, 4: Sorido).

Distribution and density of molluscs along the intertidal reefs were determined by quadrate-transect line method perpendicular to the shoreline. Sampling was carried out by walking and snorkeling on the coasts during the low tide. Transects started at the beginning of the reef flat or seagrass on the end of the beach extended to the reef crest. Therefore, the vertical spatial of the mollusc presence could be covered. Every station had one transect line with 20 plots (quadrate frame). Each transect, one quadrate (50 x 50 cm^2) was sampled every 10 m distance. Gastropods and bivalves found in each quadrate (epifauna and infauna) were counted and identified based on the morphology of the shell according to Abbott (1991), Wilson (1993), Dharma (2005), Huber (2010), Tucker and Tenorio (2013), and Poppe et al. (2014). Representative samples were collected for further investigation in the laboratory and deposited as a reference collection in the Technical Implementation Unit for Biak Marine Life Conservation – LIPI, Papua. Environmental parameters such as salinity and water temperature were measured in situ using refractometer and thermometer. The water sample for nutrient concentrations (nitrate, nitrite, phosphate) analyses was sent to Hasanuddin University, Makassar, to be measured in the laboratory using spectrophotometer. Mollusc density, Diversity Index (Shannon and Weaver 1963), Pielou Evenness Index (Pielou 1966), Dominancy Index (Simpson 1949) and Species Richness (Margalef 1969) were computed. The similarity between stations was analyzed using Bray-Curtis similarity.

The Diversity index was calculated as follows:

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where H : Shannon's diversity index
S : Total number of species in the community
Pi : Proportion of S made up of the species i

The Evenness index was calculated as follows:

$$E = \frac{H'}{H'max}$$

$$Hmax = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S$$

where E : Pielou's evenness index
H' : the number derived from H
H'max : the maximum value of H'

The Simpson's dominancy index was calculated as follows:

$$D = \frac{\sum n\,(n-1)}{N\,(N-1)}$$

where
D : Simpson's dominancy index
n : the total number of organisms of a particular species
N : the total number of organisms of all species

The Species richness index (d) was calculated as follows:

$$d = \frac{(S-1)}{\ln N}$$

where
d : Margalef's species richness index
S : the number of species recorded
N : the total number of individuals in the sample

Results

Environmental Condition

The seawater temperatures were almost the same at all 8 stations. The lowest temperature was 30.3°C at Stations 5 and 6 while the highest was 30.9°C at Stations 1 and 2. According to Banne (2005), the range of temperature that can be tolerated by macrobenthos is 25–36°C. The salinities ranged from 30 to 33 ppt. The phosphate content varied from 0.69 mg/L (Station 3) to 1.41 mg/L (Station 6), nitrate from 0.02 mg/L (Station 8) to 0.31 mg/L (Station 6), and nitrite from 0.005 mg/L (Station 4) to 0.035 mg/L (Station 3) (Table 1). Table 1 shows a relatively low environmental variation for all stations, which is a good condition for marine organisms (Kodama et al. 2012). Coastal waters in Paray (Stations 1 and 2) were dominated by seagrass *Syringodium isoetifolium*, whereas Ambroben, Yenures, and Sorido (Stations 3, 4, 5, 6, 7, 8) were dominated by seagrass *Syringodium isoetifolium* and *Thalassia hemprichii*. Substrate in Paray was dominated by sand and rubble, Ambroben was sandy mud, Yenures was rubble and dead coral, while Sorido was dominated by mud.

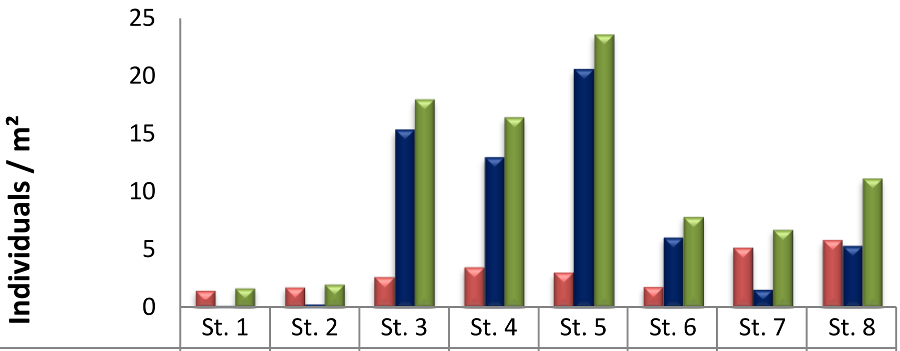
Species Composition and Description

A total of 1,751 individuals of benthic molluscs from 160 m^2 sampling site, belonging to 75 species of gastropods (502 individuals) and 19 species of bivalves (1,249 individuals) were collected. The average molluscs collected were 11 individuals/m². Station 8 showed the highest species number with 38 species and the lowest was found at Station 3 with 18 species (Table 2). The highest density of total molluscs (gastropods and bivalves) was found at Station 5 (23.6 individuals/m²) and the lowest was found at Station 1 (1.7 individuals/m²). Furthermore, the highest density of gastropods occurred at Station 8 (5.8 individuals/m²) and the lowest occurred at Station 1 (1.5 individuals/m²), while the highest density of bivalves occurred at Station 5 with 20.6 individuals/m² and the lowest occurred at Station 1 with just 0.2 individuals/m² (Figure 2).

Nassarius sp. was the most widespread genus of gastropods found in all sampling sites, followed by *Cypraea annulus* which was found in 7 stations (Table 2). Furthermore, *Strombus labiatus* was found in 6 stations and other gastropod species were found in between 1 and 5 stations. Five most abundant gastropods were *Nassarius* sp. (0.9 individuals/m²), *Cypraea annulus* (0.2 individuals/m²), *Nassarius livescens* (0.17 individuals/m²), *Nerita* sp. (0.17 individuals/m²) and *Bulla* sp. (0.14 individuals/m²). In total, there were 26 families of gastropods found in all stations. Family Conidae had the highest species number (10 species) followed by Strombidae (8 species), Cypraeidae (5 species), Naticidae (5 species), Costellaridae (4 species), and Nasaridae (4 species). Other families had between one and three species (Figure 3).

Table 1. Environmental parameters at each station.
Tabel 1. Parameter lingkungan di setiap stasiun.

Parameter	Station							
	1	2	3	4	5	6	7	8
Temperature (°C)	30.9	30.9	30.4	30.4	30.3	30.3	30.5	30.5
Salinity (‰)	30	30	33	33	30	30	32	32
Phosphate (PO_4) (mg/L)	0.91	1.35	0.69	0.97	0.97	1.41	0.78	1.05
Nitrate (NO_3) (mg/L)	0.09	0.12	0.06	0.05	0.09	0.31	0.04	0.02
Nitrite (NO_2) (mg/L)	0.020	0.024	0.035	0.005	0.022	0.030	0.028	0.018



	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8
Gastropods (indv/m²)	1.5	1.75	2.65	3.45	3	1.8	5.15	5.8
Bivalves (indv/m²)	0.2	0.3	15.35	13	20.6	6.05	1.6	5.35
Total Molluscs (indv/m²)	1.7	2.05	18	16.45	23.6	7.85	6.75	11.15

Figure 2. Total species and density (individuals/m²) at each station in South Biak.
Gambar 2. Jumlah spesies dan kepadatan (individu/m²) di setiap stasiun Biak Selatan.

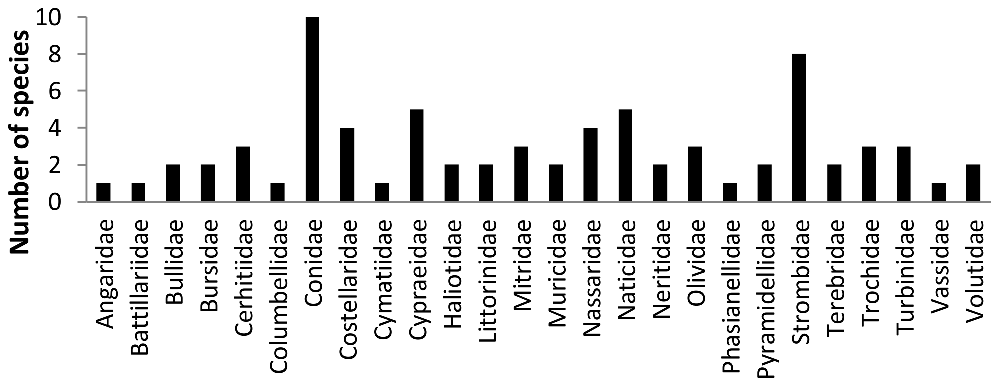


Figure 3. Family of gastropods at all stations in South Biak.
Gambar 3. Famili Gastropoda di semua stasiun Biak Selatan.

The most widespread bivalve was *Tellina* sp. found in seven stations. The second most widespread was *Trachycardium* sp. which was found in five stations (Table 2). Species *Corculum cardissa*, *Donax trunculus*, *Perna viridis*, *Asaphis deflorata*, *Asaphis* sp., *Pinctada maxima*, *Pinctada margaritifera*, *Spondylus squamosus*, and *Musculium* sp. occurred only in one station. Five most abundant bivalves were *Modiolus* sp. (3 individuals/m²), *Tellina* sp. (2.8 individuals/m²), *Perna viridis* (1.1 individuals/m²), *Mytillus* sp. (0.3 individuals/m²), and *Codakia tigerina* (0.1 individuals/m²). A total of 12 families of bivalves were found in all stations with Mytilidae had the highest number of species (3 species), followed by Cardidae, Pinnidae, Psammobidae, Pteridae, and Tellinidae each with two species, while Arcidae, Donacidae, Isognominidae, Lucinidae, Spondylidae, and Veneridae were each with one species (Figure 4).

The highest value of diversity index Shannon-Wiener (H) was obtained at Station 1 (2.96) and the lowest at Station 5 (0.83) (Table 3). In addition, Evenness (Pielou) (E), Richness (Margalef) (d) and Dominancy (Simpson) (D) indexes were also calculated with the highest value obtained at Station 1 (0.96), Station 8 (6.84), and Station 5 (0.724) respectively. On the contrary, the lowest value of Evenness (Pielou), Richness (Margalef), and Dominancy (Simpson) indexes were obtained at Station 5 (0.27), Station 3 (2.89), and Station 1 (0.059) respectively.

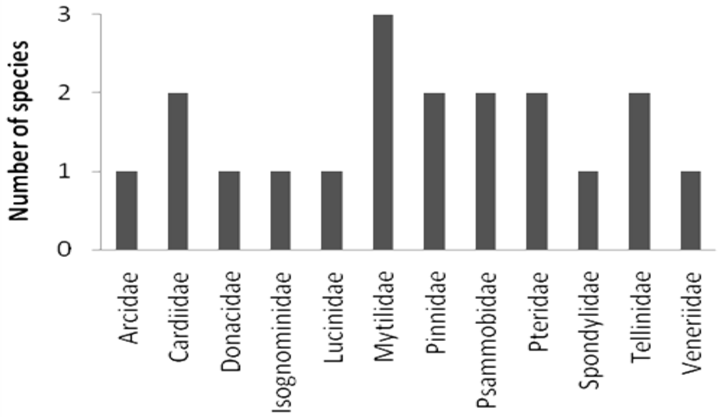


Figure 4. Families of bivalves at all stations in South Biak.
Gambar 4. Famili Bivalvia di semua stasiun Biak Selatan.

Table 2. Species composition in the study areas.
Tabel 2. Komposisi spesies di lokasi penelitian.

No	Family	Species	Station								Total
			1	2	3	4	5	6	7	8	
I	**GASTROPODS**										
1	Angaridae	*Angaria delphinus*	0	2	0	0	1	0	0	0	**3**
2	Battillariidae	*Battilaria minima*	0	0	0	0	0	0	19	0	**19**
3	Bullidae	*Bulla vernicosa*	0	0	0	0	2	0	0	0	**2**
4	Bullidae	*Bulla* sp.	2	0	10	0	7	0	0	3	**22**
5	Bursidae	*Bursa elegans*	0	0	0	0	0	0	2	1	**3**
6	Bursidae	*Bursa* sp.	0	0	1	8	2	2	0	0	**13**
7	Cerhitiidae	*Cerithium kobelty*	0	0	0	0	1	0	0	0	**1**
8	Cerhitiidae	*Rhinoclavis vertagus*	0	0	0	0	0	0	6	1	**7**
9	Cerhitiidae	*R. kochi*	1	0	0	0	0	0	0	0	**1**
10	Columbellidae	*Columbella* sp.	0	0	0	0	5	0	0	0	**5**
11	Conidae	*Conus vexillum*	0	0	1	0	0	0	0	0	**1**
12	Conidae	*C. vitulinus*	0	1	0	0	0	0	0	0	**1**
13	Conidae	*C. planorbis*	0	0	0	1	0	0	0	0	**1**
14	Conidae	*C. filicinatus*	0	0	0	0	0	1	0	0	**1**
15	Conidae	*C. magus*	1	0	0	1	1	0	0	0	**3**
16	Conidae	*C. litteratus*	0	1	0	0	0	5	0	0	**6**
17	Conidae	*C. virgo*	0	0	0	0	0	1	1	0	**2**
18	Conidae	*C. textile*	0	2	0	0	0	1	0	0	**3**
19	Conidae	*C. marmoreus*	0	0	0	0	0	0	0	1	**1**
20	Conidae	*C. eburneus*	0	0	0	0	0	0	0	1	**1**
21	Costellaridae	*Vexillum virgo*	0	0	0	0	0	0	2	0	**2**
22	Costellaridae	*V. rugosum*	0	0	1	2	2	0	0	3	**8**
23	Costellaridae	*Vexillum* sp.	1	0	1	0	1	0	0	0	**3**
24	Costellaridae	*V. curviliratum*	0	0	0	1	0	1	0	0	**2**
25	Cymatiidae	*Cymatium mundum*	0	0	0	0	0	0	0	1	**1**

26	Cypraeidae	*Monetaria annulus*	2	7	3	1	11	0	0	7	**31**
27	Cypraeidae	*M. moneta*	0	2	0	0	0	0	0	0	**2**
28	Cypraeidae	*Cypraea erosa*	0	0	0	0	0	0	0	1	**1**
29	Cypraeidae	*C. cylindrical*	0	0	0	3	1	0	0	2	**6**
30	Cypraeidae	*Cypraea* sp.	0	0	1	0	0	0	1	0	**2**
31	Haliotidae	*Haliotis asinina*	0	1	0	0	0	0	0	0	**1**
32	Haliotidae	*H. ovina*	0	0	0	0	0	1	0	0	**1**
33	Littorinidae	*Nodilittorina gyramidalis*	3	0	0	0	0	0	0	0	**3**
34	Littorinidae	*Hirthia littorina*	0	0	0	0	0	0	0	1	**1**
35	Mitridae	*Mitra* sp.	0	0	0	0	0	0	0	2	**2**
36	Mitridae	*M. paupercula*	1	0	0	0	0	0	0	0	**1**
37	Mitridae	*M. mitra*	0	0	0	0	3	0	1	0	**4**
38	Muricidae	*Drupella* sp.	0	0	1	0	0	0	1	0	**2**
39	Muricidae	*Thais bufo*	0	0	0	0	0	0	2	3	**5**
40	Nassaridae	*Nassarius* sp.	2	1	25	34	10	7	33	38	**150**
41	Nassaridae	*N. pyrrhus*	0	0	0	0	0	6	0	3	**9**
42	Nassaridae	*N. livescens*	1	3	0	3	5	0	2	13	**27**
43	Nassaridae	*N. globosus*	0	0	0	0	0	0	0	7	**7**
44	Naticidae	*Natica* sp.	0	0	0	0	0	0	12	0	**12**
45	Naticidae	*Polinices melanostopus*	0	0	0	1	0	5	1	0	**7**
46	Naticidae	*P. sebae*	1	0	0	0	0	2	0	2	**5**
47	Naticidae	*P. aurantius*	1	0	0	0	0	1	1	1	**4**
48	Naticidae	*Natica simplex*	0	0	0	1	0	0	5	0	**6**
49	Neritidae	*Neritopsis radula*	0	1	0	0	0	0	0	2	**3**
50	Neritidae	*Nerita* sp.	0	5	3	4	0	0	6	9	**27**
51	Olividae	*Oliva funebralis*	0	1	0	0	0	0	0	1	**2**
52	Olividae	*O. olive*	0	0	1	0	0	0	0	0	**1**
53	Olividae	*O. reticulata*	1	0	0	0	0	0	0	1	**2**
54	Phasianellidae	*Phasianella variegata*	0	0	0	0	0	0	0	1	**1**
55	Pyramidellidae	*Pyramidella sulchata*	0	0	0	6	0	0	0	0	**6**
56	Pyramidellidae	*Pyramidella* sp.	0	1	0	0	1	0	0	0	**2**
57	Strombidae	*Lentigo lentiginosus*	0	0	0	0	0	0	5	0	**5**
58	Strombidae	*Lambis lambis*	0	2	0	0	0	1	0	0	**3**
59	Strombidae	*Strombus marginatus*	1	0	3	0	0	0	0	1	**5**
60	Strombidae	*Canarium labiatus*	0	1	2	1	0	1	0	1	**6**
61	Strombidae	*Conomurex luhuanus*	2	0	0	0	0	0	1	0	**3**
62	Strombidae	*Strombus* sp.	3	1	0	0	0	0	0	0	**4**
63	Strombidae	*Lambis millipeda*	0	0	0	1	0	0	0	1	**2**
64	Strombidae	*L. scorpius*	0	0	0	0	0	0	0	2	**2**
65	Terebridae	*Terebra babylonia*	0	0	0	0	6	0	0	0	**6**
66	Terebridae	*T. maculata*	0	0	0	0	0	0	0	1	**1**
67	Trochidae	*Trochus niloticus*	1	2	0	0	0	0	0	0	**3**
68	Trochidae	*Tectus fenestratus*	0	1	0	1	0	0	0	2	**4**
69	Trochidae	*Monodonta labio*	1	0	0	0	0	0	0	0	**1**

70	Turbinidae	*Turbo marmoreus*	0	0	0	0	1	0	0	1	**2**
71	Turbinidae	*T. petolatus*	0	0	0	0	0	0	0	2	**2**
72	Turbinidae	*Astraea calcar*	0	0	0	0	0	1	0	0	**1**
73	Vassidae	*Vassum ceramicum*	4	0	0	0	0	0	0	0	**4**
74	Volutidae	*Cymbiola* sp.	1	0	0	0	0	0	0	0	**1**
75	Volutidae	*C. vespertilio*	0	0	0	0	0	0	2	0	**2**
II	**BIVALVES**										
76	Arcidae	*Anadara antiquate*	0	0	0	1	0	0	0	1	**2**
77	Cardiidae	*Trachycardium* sp.	1	0	3	1	5	1	0	0	**11**
78	Cardiidae	*Corculum cardissa*	0	0	0	0	0	0	1	0	**1**
79	Donacidae	*Donax trunculus*	0	0	0	0	0	0	0	1	**1**
80	Isognominidae	*Isognomon perna*	0	0	0	0	4	5	0	0	**9**
81	Lucinidae	*Codakia tigerina*	0	0	16	2	0	0	0	0	**18**
82	Mytilidae	*Perna viridis*	0	0	180	0	0	0	0	0	**180**
83	Mytilidae	*Mytillus* sp.	0	0	0	0	0	3	1	49	**53**
84	Mytilidae	*Modiolus* sp.	0	0	0	0	401	108	0	0	**509**
85	Pinnidae	*Pinna muricata*	0	0	1	4	0	0	0	0	**5**
86	Pinnidae	*Atrina vexillum*	0	1	0	0	1	0	0	0	**2**
87	Psammobidae	*Asaphis deflorata*	0	0	0	0	0	0	0	1	**1**
88	Psammobidae	*Asaphis* sp.	0	0	0	3	0	0	0	0	**3**
89	Pteridae	*Pinctada maxima*	0	1	0	0	0	0	0	0	**1**
90	Pteridae	*P. margaritifera*	0	0	0	0	0	3	0	0	**3**
91	Spondylidae	*Spondylus squamosus*	0	0	0	0	1	0	0	0	**1**
92	Tellinidae	*Tellina* sp.	2	4	107	249	0	1	28	54	**445**
93	Tellinidae	*Musculium lacustre*	1	0	0	0	0	0	0	0	**1**
94	Veneriidae	*Gafrarium tumidum*	0	0	0	0	0	0	2	1	**3**
	Total species		**22**	**21**	**18**	**22**	**22**	**21**	**23**	**38**	

Table 3. Diversity index of molluscs from 8 stations.
Tabel 3. Indeks keanekaragaman moluska di 8 stasiun.

Index	**Station**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Evenness (Pielou) (E)	0.96	0.92	0.50	0.36	0.27	0.48	0.76	0.69
Diversity (Shannon-Wiener) (H)	2.96	2.80	1.45	1.10	0.83	1.47	2.38	2.50
Richness (Margalef) (d)	5.95	5.38	2.89	3.62	3.41	3.95	4.48	6.84
Dominancy (Simpson)	0.06	0.08	0.35	0.58	0.72	0.48	0.14	0.15

Similarity index is used to measure the level of similarity between different samples or communities. Based on the values of similarity index for all stations, the highest similarity was found in Stations 7 and 8 which both stations are located in Sorido (42.5%), while the lowest was found in Station 1 which is located in Paray and Station 5 which is located in Yenures (3.9%) (Table 4). To get a better visual overview, a cluster dendrogram was made of the same data used for similarity value. It was shown in dendrogram of Bray Curtis analysis (Figure 5) that the types of mollusc community in South Biak may be classified into three groups based on the diversity and the dominancy of species. Group 1 comprises of Stations 1 and 2, Group 2

Table 4. Value of similarity index for all stations.
Tabel 4. Nilai indeks kesamaan untuk semua stasiun.

Station	1	2	3	4	5	6	7	8
1	*	21.33	5.58	4.41	3.95	6.28	8.28	10.12
2	*	*	5.98	8.11	5.46	6.06	13.64	18.18
3	*	*	*	41.51	6.25	4.25	23.43	31.22
4	*	*	*	*	5.24	5.76	29.74	37.68
5	*	*	*	*	*	38.79	4.28	8.34
6	*	*	*	*	*	*	8.22	9.47
7	*	*	*	*	*	*	*	42.46

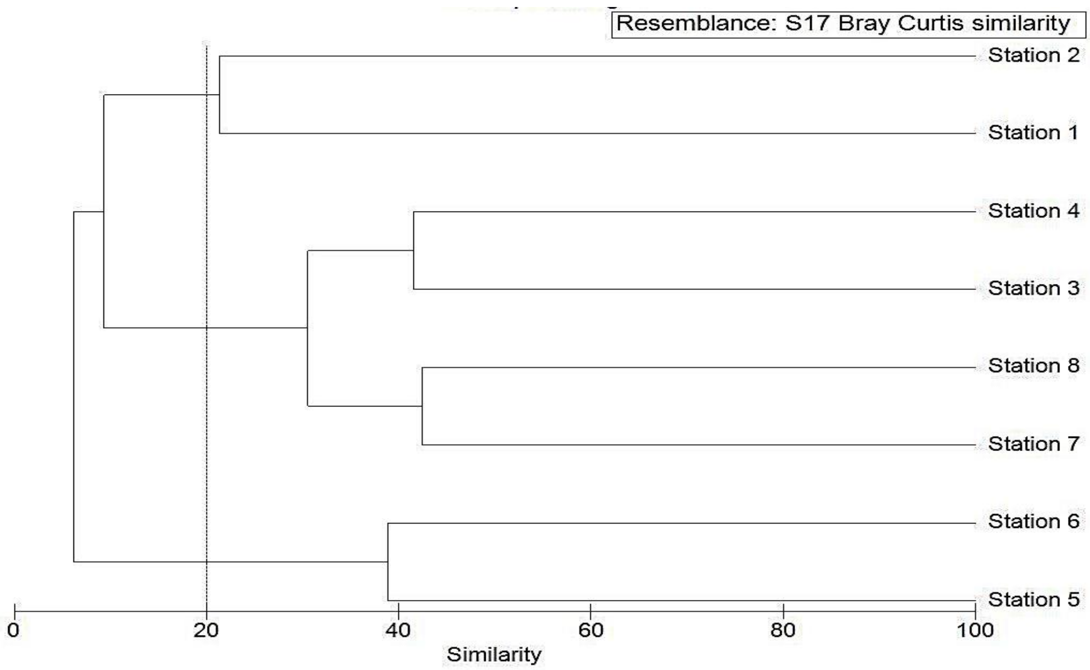


Figure 5. Dendrogram of Bray-Curtis analysis (with cut off 20% similarity)
Gambar 5. Analisis dendrogram Bray-Curtis (dengan potongan garis kesamaan 20%)

comprises of Stations 5 and 6, while Group 3 comprises of Stations 3, 4, 7, and 8.

Discussion

Species Composition

The highest density of bivalves occurred at Station 5 and the lowest was at Station 1. The highest density of bivalves at Station 5 was due to the presence of *Modiolus* sp. attached to the substrates. *Modiolus* sp. stay or partially buried in the substrate, produced byssus threads to anchor to the ground. The byssus threads have an important stabilizing effect on the seabed, binding together living *Modiolus* sp., dead shell, and sediments. Therefore, they can easily colonize the hard substrates which make them have a high density.

One of the most widely distributed genus in the family Tellinidae is *Tellina*. *Tellina* sp. was present in all stations, except for Yenures 1. *Tellina* sp. is a deep burrower in sand or mud, and mostly, they can be found in clean silty sand, sand or muddy sand of the intertidal zone (Creutzberg 1986). The condition of most of the stations was clean sand, a suitable habitat for this species.

Nassarius sp. was the most widespread genus of gastropods that was found in all stations, followed by *Cypraea annulus* which was found in seven stations (Table 2). The microhabitat of *Nassarius* sp. is sand, while *Cypraea annulus* was found in the sand, rocks or seagrass beds. Most of the stations have sand, rock substrate, and seagrass bed, therefore these two species can be found in almost all stations.

Ninety four species of molluscs from South Biak reported here were relatively high. In some places, however, the species number of molluscs were higher i.e. 103 species in Kei Kecil Islands, Southeast Moluccas (Kusnadi et al. 2008), 128 species in Likupang, North Sulawesi (Arbi 2009), 92 species in Lembeh Strait, North Sulawesi (Arbi 2010), 182 species found in Talise Island, North Sulawesi (Arbi 2011), 36 species in Gilimanuk Bay, Bali (Cappenberg et al. 2006), 31 species in Segara Beach Sanur, Bali (Istiqlal et al. 2013), 76 species in Derawan Island (Mudjiono 2002), and 83 species in Natuna, Riau Islands (Mudjiono 2009).

Community Structure

Diversity index Shannon-Wiener (H) was calculated for all stations with the highest value at Station 1 (2.96) and the lowest at Station 5 (0.83) (Table 3). If diversity index (H) is more than two, it is categorized as high and if it is below one, it is categorized as low. High diversity value assumes that the community is stable and low diversity is unstable (Pavoine and Bonsall 2011).

Stations 1 and 2 are part of a marine protected area, the biodiversity indices (2.96 and 2.8 respectively) were categorized as high, which mean the benthic mollusc community, was living well in a stable condition. At these stations all molluscs existed evenly in the community and there was no dominant species. This location consists of a heterogeneous substrate such as coarse sand, fine sand, rubble, and a stretch of seagrass bed with an average coverage of 50%, was suitable for molluscs. The high diversity of molluscs possibly because of it is a marine protected area, therefore there is no fishing activity by local people.

Similarly, at Stations 7 and 8, the quite high values of H also showed that these communities have high complexity due to the high interaction of the community types. The interaction that involves the transfer of energy, predation, competition, and the distribution of niches is more complex in the community with high diversity (Pavoine and Bonsall 2011). The concept of diversity can be used to measure the ability of a community to keep the community stability, even though there is disruption of its components (Taqwa 2010).

At Stations 3, 4, and 5 the mollusc community was in an unstable condition as there were not many species living in these locations. At Stations 3 and 4, *Nassarius* sp., *Tellina* sp. were dominat, while *Perna viridis* was dominant in Station 3, while other species were found in small numbers of individuals. The Stations 3 and 4 are located in the area with a lot of organic and anorganic waste such as plastics and debris of food and trees. Therefore, only some species can adapt to such environment. The bivalve encountered at Stations 3 and 4 were *Tellina* sp. They were numerous in small size (approximately 5 mm to 3 cm) and found in a very smooth substrate at the seagrass meadow. *Modiolus* sp. was also found in Stations 5 and 6 in large numbers, attached to the rock. Stations 5 and 6 showed a low diversity index with the lowest value is 0.83 in Station 5. This low index because of the presence of *Modiolus* sp. in high number of individuals. This bivalve is common in seagrass area at Station 5. It is possible that *Modiolus* sp. can be found in large number because the local people do not use that species for food or ornamental shell. The dominance index in Station 5 was the highest (Table 3).

Richness index of molluscs in South Biak coastal waters showed in Table 3, the index (d) ranged from 2.89 (Station 3) to 6.84 (Station 8). Margalef (species richness) index is focusing on the number of species in relation to the number of individuals. The stations with high species richness also have high value of diversity index as in Stations 1, 2, 7, and 8. These stations also have low dominancy index. Species richness influences the value of diversity index and contributes to the maturity and complexness of the community itself. Hence, the community will have a good ability not to be easily affected by the disturbance and it will make the community more stable (Margalef 1969).

The Simpson or dominancy index ranged from 0.06 (Station 1) to 0.72 (Station 5) (Table 3). Stations 5, 4, and 6 have relatively higher dominancy index than other stations with dominancy index of 0.72, 0.59, and 0.48 respectively. Stations 5 and 6 were dominated by *Modiolus* sp. because the hard substrate that was on the reef flat or near the beaches were the most suitable attachment sites for *Modiolus* sp. although some of them also found buried in coarse grounds. Station 4 was dominated by *Tellina* sp. as the majority of substrate is sandy mud which was suitable for *Tellina* sp. (Creutzberg 1986). According to Simpson (1949), the Simpson's Index (D) reflects the probability that two individuals randomly taken from a sample will belong to the same species. Higher value of Simpson's index (D) will result in the dominancy of some species in that community it will then influence the diversity in the community.

The evenness index at all stations ranged from 0.27 (Station 5) to 0.96 (Station 1) (Table 3). It showed that the higher value of Simpson index will result in the lower value of evenness index and Shanon-Wiener diversity index. The range of evenness index is from 0 to 1 with 1 representing a situation in which all species are equally abundant. The less variation in the communities between the species, the higher evenness index value. The Stations 1, 2, 7, and 8 have the evenness index more than 0.5 (Table 3). There were 4 stations with the value of evenness index is above 0.5 which were Stations 1 (0.96), 2 (0.92), 7 (0.76), and 8 (0.68). Stations 1 and 2 have the evenness index 0.96 and 0.92 respectively, or nearly 1, which means the distribution of the individuals of each species is equal and equitable in the sampling sites. Stations 4, 5, and 6 have lower evenness index (0.36, 0.27, and 0.48 respectively) which means the homogeneity of species abundance in the community is low. In the Stations 4, 5, and 6 the distribution of individuals among the species is not equal in number. This is because of the dominancy of species, particularly *Nassarius* sp. and *Tellina* sp. found at Station 4 and *Modiolus* sp. at Stations 5 and 6. This phenomenon may be related with the substrates that are suitable for those dominant species. Another reason was that *Nassarius* sp. and *Modiolus* sp. do not have economic value for local people, therefore those species are not exploited.

Similarity index is used to measure the level of similarity between communities. Based on Figure 4 and Figure 5, the types of mollusc community in South Biak may be categorized into three groups. Group 1 consists of Stations 1 and 2 that are located in Paray which is a marine protected area and they have high diversity index value. There is no dominant species found in this group and all species are distributed equally in the ecosystem. It can be noticed that high diversity of molluscs in Stations 1 and 2 was influenced by the heterogeneity of the substrate. Group 2 consists of Stations 5 and 6 which are located in Yenures. This group has the lowest diversity index due to the dominancy of species and unequally distributed species among the communities. Both stations have high dominancy of *Modiolus* sp. from family Mytilidae. These two stations can be grouped together as they have hard substrate that is suitable for *Modiolus* sp. to attach their byssus. Moreover, the people who live in that area are not collecting *Modiolus* sp. Therefore, *Modiolus* sp. is the most dominating species. Moreover, Group 3 consists of Stations 3, 4, 7, and 8. Stations 3 and 4 are located in Ambroben and Stations 7 and 8 are located in Sorido. The Group 3 has very high dominancy of bivalvia *Tellina* sp. (Tellinidae) and gastropoda *Nassarius* sp. In these four stations, the condition of the substrate is mostly silty or muddy sand. Thus, it is suitable for bivalvia *Tellina* sp. and gastropoda *Nassarius* sp. to live in this area.

Conclusion

The benthic mollusc diversity in South Biak, Papua, was high with 94 species (75 gastropods and 19 bivalves). The most widespread gastropod found in all stations was *Nassarius* sp., followed by *Cypraea annulus*, *Nassarius livescens*, while for bivalves it was *Tellina* sp.. In general, diversity index of mollusc in South Biak waters are in high state. To get a complete picture of the diversity of mollusc species and their distribution in South Biak waters, it is necessary to continue this study. Good management and conservation for benthic molluscs are needed to maintain benthic mollusc diversity in this area. Local government should introduce marine protected area in Yenures to protect mollusc diversity, as this area has the lowest diversity index compared to Paray, Ambroben, and Sorido.

Acknowledgement

We are grateful to all the staff (researcher and technician) of the Technical Implementation Unit for Marine Life Conservation Biak - LIPI, Papua for their assistance in collecting the data. This work was supported by “Program Insentif Ristek 2011”. The comments of anonymous reviewers that improved the manuscript are greatly appreciated.

References

Abbott, R. T., and S. P. Dance. 2000. Compendium of seashells: A full-color guide to more than 4,200 of the world's marine shells. Odyssey Publishing. USA. 411 pp.

Aji, L.P., Latanda, and J. Lorwens. 2015. Laporan Monitoring Kesehatan Terumbu Karang Kabupaten Biak Numfor. Dinas Kelautan dan Perikanan Kabupaten. Biak Numfor. 65 pp.

Arbi, U. Y. 2009. Komunitas moluska di padang lamun perairan Likupang, Sulawesi Utara. Oseanologi and Limnologi di Indonesia, 35(3):417–434.

Arbi, U. Y. 2010. Moluska di pesisir barat perairan Selat Lembeh, Kota Bitung, Sulawesi Utara. Jurnal Bumi Lestari, 10(1): 60–68.

Arbi, U.Y. 2011. Struktur komunitas moluska di padang lamun perairan Pulau Talise, Sulawesi Utara. Oseanologi dan Limnologi di Indonesia 37(1):71–89.

Banne, Y. 2005. Struktur komunitas makrozoobenthos pantai Losari Makassar Sulawesi Selatan. Skripsi Fakultas Ilmu Kelautan dan Perikanan. Universitas Hasanuddin. Makassar. 71 pp.

Cappenberg, H. A. W., A. Aziz, and I. Aswandy 2006. Komunitas moluska di perairan Teluk Gilimanuk, Bali barat. Oseanologi dan Limnologi di Indonesia 40:53–64.

Creutzberg, F. 1986. Distribution patterns of two bivalve species (*Nucula turgid*, *Tellina fabula*) along a frontal system in the Southern Nort Sea. Netherlands Journal of Sea Research 20:305–311.

Dharma, B. 2005. Recent and fossil Indonesian shells. Conchbooks Hackenheim. Germany. 424 pp.

Hickman, C. P., Roberts, L. S., and Larson, A. 2004. Integrated Principles of Zoology Ninth Edition. Updated Version. Brown Publishers. Dubuque Iowa.

Huber, M. 2010. Compendium of bivalves: A Full-color guide to 3'300 of the world's marine bivalves, A status on bivalvia after 250 years of research. ConchBooks Hackenheim. Germany. 901 pp.

Istiqlal, B. Y., D. S. Yusup, and N. M.Suartini. 2013. Distribusi horizontal moluska di kawasan padang lamun pantai Merta Segara Sanur, Denpasar. Jurnal Biologi XVII(1):10–14.

Kodama, K., J. H. Lee, M. Oyama, H. Shiraishi, and T. Horiguchi. 2012. Disturbance of benthic macrofauna in relation to hypoxia and organic enrichment in a eutrophic coastal bay. Marine Environmental Research 76(0):80–89.

Kusnadi, A., T.Triandiza and U.E.Hernawan. 2008. Inventarisasi jenis dan potensi moluska padang lamun di kepulauan Kei Kecil, Maluku Tenggara. Biodiversitas 9(1):30–34.

Margalef, R. 1969. Perspectives in Ecological Theory. The University of Chicago Press, Chicago, 111 pp.

Mudjiono. 2002. Komunitas moluska (keong dan kerang) di rataan terumbu kepulauan Derawan, Kalimantan Timur. Page 75–82. *In* Perairan Sulawesi dan sekitarnya: biologi, lingkungan dan oseanografi, Pusat Penelitian Oseanografi. LIPI.

Mudjiono. 2009. Telaah komunitas moluska di rataan terumbu perairan kepulauan Natuna Besar, Kabupaten Natuna. Oseanologi dan Limnologi di Indonesia 35(2):151–166.

Pavoine, S., and M. B. Bonsall. 2011. Measuring biodiversity to explain community assembly: a unified approach. Biological Reviews 86(4):792–812.

Pielou, E. C. 1966. Shannon's formula as a measure of specific diversity: its use and measure. American Naturalist 100: 463–465.

Poppe, G. T., P. Poppe, and S. P. Tagaro. 2014. 1000 Shells Exceptionals from the Philippines. Conch Books Hackenheim. Germany. 897 pp.

Shannon C. E., and W. Weaver. 1963. The mathematical theory of communication. Urbana, Illinois: University of Chicago Press. 117 pp.

Simpson, E. H. 1949. Measurement of diversity. Nature 163:688 pp.

Taqwa, A. 2010. Analisis produktivitas primer fitoplankton dan struktur komunitas fauna makrobenthos berdasarkan kerapatan mangrove di kawasan konservasi mangrove dan Bekantan Kota Tarakan, Kalimantan Timur. Tesis. Program Pascasarjana Universitas Diponegoro.Semarang. 97 pp.

Tucker J. K., and M. J. Tenorio. 2013. Illustrated catalog of the living cone shells. Wellington, Florida: MdM Publishing. 517 pp.

Urra, J., Á. M. Ramírez, P. Marina, C. Salas, S. Gofas, and J. L. Rueda. 2013. Highly diverse molluscan assemblages of Posidoniaoceanica meadows in northwestern Alboran Sea (W Mediterranean): Seasonal dynamics and environmental drivers. Estuarine, Coastal and Shelf Science 117:136–147.

van der Meij, S. E. T., R. G. Moolenbeek, and B. W. Hoeksema. 2009. Decline of the Jakarta

Bay molluscan fauna linked to human impact. Marine Pollution Bulletin 59:101–107.

Wells, F. E. 1998. Marine molluscs of milne bay province, Papua New Guinea. Page 35–38. *In* T. Werner and G. R. Allem (Eds.). A rapid biodiversity assessment of the coral reefs of Milne bay Province, Papua New Guinea. RAP Working Papers Number 11. Washington, DC: Conservation International.

Wells, F. E. 2000. Molluscs of the calamianes group, Philippines. 129 pp. *In* T. B.Werner, and G. R. Allen (Eds.). A rapid marine biodiversity assessment of the Calamianes Islands, Palawan Province, Philippines. Bulletin of the Rapid Assessment Program 17, Conservation International, Washington DC.

Wells, F. E. 2002. Molluscs of the Raja Ampat Islands, Indonesia.191 pages. *In* McKenna, S. A., G. R. Allen, and S. Suryadi (Eds.). A marine rapid assessment of the Raja Ampat Islands, Papua Province, Indonesia. Bulletin of the Rapid Assessment Program 22, Conservation International, Washington DC.

Widyastuti, A., A. B. Sitepu, L. P. Aji. 2013. Keragaman Moluska Pesisir Biak.UPT Loka Konservasi Biota Laut Biak – Puslit Oseanografi LIPI. 112 pp.

Wilson, B. 1993. Australian marine shells: Prosobranch Gastropods. Vol I. Odysey Publishing. Australia. 408 pp.