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DISTRIBUTION FEATURES OF MEASURED WAVE CHARACTERISTICS IN COASTAL WATERS OF NINH THUAN PROVINCE, VIETNAM

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Abstract. This paper presents the distribution features of wave characteristics based on the continued measurement wave data with interval of 1 hour from January to December 2013 in coastal waters of Ninh Thuan province. The study results show that the dominant wave directions were in East-North-East (ENE), East (E), South-South-East (SSE) and South-East (SE) with occurrence frequency of 36.7%, 20.5%, 18.2% and 11.6% respectively. During North-East (NE) monsoon the dominant wave directions were in ENE and E. During South-West (SW) monsoon the dominant wave directions were in SSE and SE. The remaining directions were rare. The maximum values of wave height (H_{max}) was 4.84 m (11/2013), wave period (T) was 10.9 s (11/2013). The occurrence frequency of $H_s \leq 0.5$ m was 43.9%, $H_s \approx 0.5$–1.0m was 21.9%, $H_s \approx 0.5$–1.0 m was 21.9%, $H_s \approx 1.0$–2.0 m was 27.3%, $H_s > 2.0$ m was 6.8% and calm wave condition ($H_s \leq 0.25$ m) was 8.1%. The duration and intensity of wave action were dominant in NE monsoon period.

Keywords: Significant wave height (H_s), maximum wave height, Ninh Thuan, monsoon, coastal zone.

INTRODUCTION

The East Sea is under the influence of monsoon winds and synoptic systems such as fronts and tropical cyclones. From November to March, the weather in the sea is dominated by northeasterly winter monsoon wind and from June to August it is dominated by southwesterly summer monsoon wind. Vietnam is located in the South-East of Asia and to the West of the East Sea, has 3,200 km long coastline and many islands. Most of the provinces of Vietnam are located along the coastline. The coastal zone has an important role in the economy of Vietnam through ports and harbours, marine fisheries, tourism, aquaculture, petroleum industries and environment protection. Wave characteristics are the important factors in hydro-litho-dynamic processes in the coastal zone and have strong effects on economic and environment protection activities. Therefore, determination of wave characteristics in the nearshore region has important role for design of marine structures, social-economical activities... Processes of formation, development and dissipation of wave corresponding to the varied conditions of wind, current and topography are very complicated matters.

To obtain the wave regime at study area the best choice is direct observation, but this way is still limited in Vietnam since it needs modern equipment and finance. The historical development of measured wave equipment was step by step modernized from using object-finder, electrical resistance cable to pressure sensors which were installed to AWAC, buoy

instruments,... Beside, the wave characteristics are also observed by satellite and radar equipment [1]. From 2009 the Center for Oceanography, Ministry of Natural Resources and Environment (MONRE) has installed equipment to measure wave and current by radar high frequency system (4.3–5.4 MHz) at three stations at Quang Binh, Ha Tinh and Hai Phong provinces [2]. The central station at Ha Noi controls and manages the transmission and reception of signal from 3 stations based on installed softwares in a server which has automatically received data with frequency of 24/24 h in a day. However, the radar data only cover the Tonkin Gulf area. At present the observed wave data in Southern Vietnam waters are rare.

This paper presents the distribution features of measured wave characteristics based on the continued measurement with interval of 1 hour from January to December 2013 in coastal waters of Ninh Thuan province. Location of study area is shown in fig. 1.

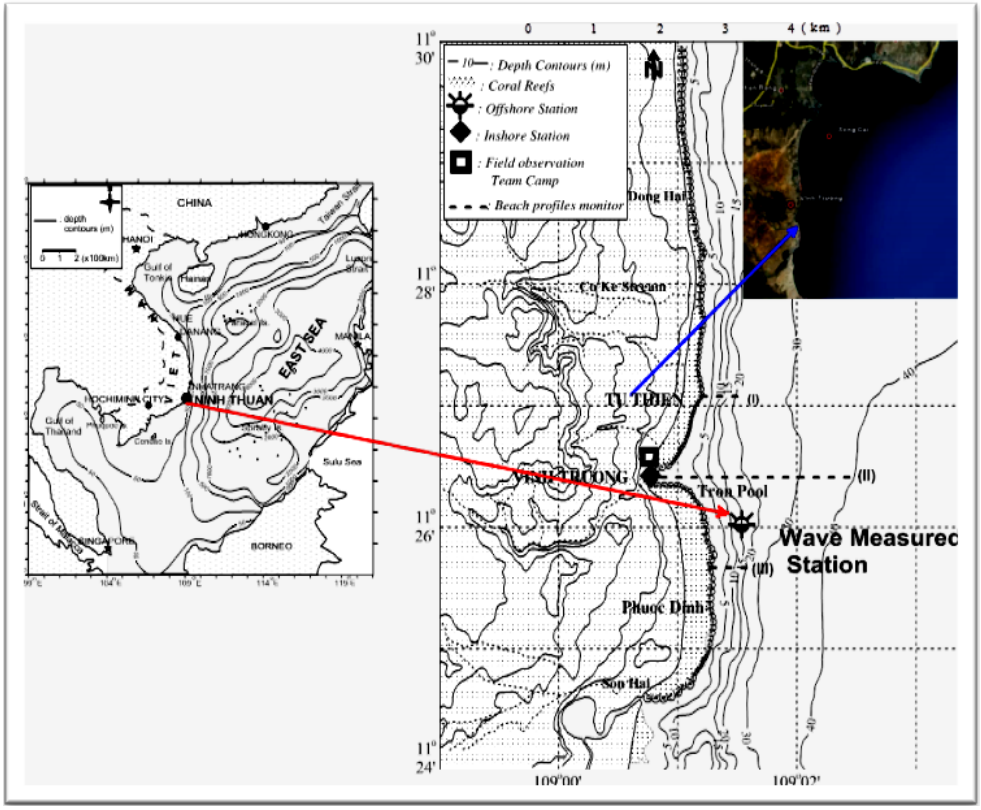

Fig. 1. Location of wave measurement station

MATERIAL AND METHOD

The field survey was carried out in accordance with the Circular No. 34/2010/TT-BTNMT: "The regulation for survey and investigation of the oceanography, chemistry and environment in the coastal and island areas" dated December, 2010 issued by the Vietnamese Ministry of Natural Resources and Environment. Wind regime in the offshore region of study area can be taken from Phu Quy island wind station (1979–2012) which was measured with the interval of 6 h. Typhoon data along the coast from Da Nang to Binh Thuan (1945–2010) were collected from www.weather.unisys.com/hurricane (National Weather Service, USA).

The automatic gauging station is placed within the study area, as it is shown in fig. 1 in Vinh Truong hamlet, Phuoc Dinh commune, Thuan Nam district, Ninh Thuan

province. The work was carried out based on the Contract No. 142/HD-TV2-P02 dated 7/6/2012 between the Power Engineering Consulting Joint Stock Company 2 (PECC2) with the Institute of Oceanography for subconsultant's services for surveys and investigation for the development of site approval dossier and environment impact assessment (EIA) of Ninh Thuan 1 Nuclear Power Plant Project. The measured station is at depth of about 20 m and offshore about 1.5 km with the coordinate of 109°1'10"E, 11°26'13"N by AWAC equipment (Made in Norway), fig. 1.

STUDY RESULTS

Related natural conditions. Ninh Thuan waters has narrow continental shelf and direct interaction with hydro-dynamical processes from open sea such as wind, wave, current, storm-surge... Main oceanographical processes are irregular dual tide with mean high tide of about 2 m. Wind regime in the offshore region of study area can be taken from Phu Quy island Station. The wind data show that the study area undergoes the effect of seasonal wind regime: NE and SW monsoons. The main wind directions are from NE and SW (fig. 2).

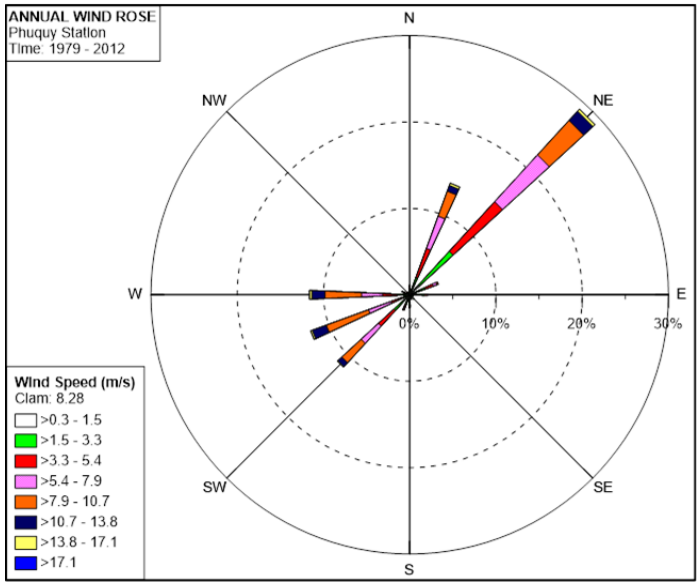

Fig. 2. Annual wind rose diagram at Phu Quy Station (1979–2012)

Occurrence of typhoon along the coast from Da Nang to Binh Thuan were dominant in October, November and December (table 1).

Table 1. Occurrence of typhoon along the coast from Da Nang to Binh Thuan (1945–2010)

Months	5	6	7	8	9	10	11	12
Number of typhoon	2	0	1	0	5	22	28	9
Rate (%)	3.0	0.0	1.5	0.0	7.5	32.8	41.8	13.4

The above mentioned information show that the deploying site of AWAC equipment is most strongly affected by wave action from NE-E directions. That means the study site is strongly affected by wave action during NE monsoon and typhoon activity period (October–December) and less affected during SW monsoon. However, wave energy from open sea especially in case of strong wave was strongly transformed by the effects of morphological conditions such as shallow water and shoreline direction.

Distribution features of measured wave characteristics. Statistic results of distribution features of measured wave height and direction for the year 2013 show the dominant wave directions were in ENE, E, SSE and SE with occurrence frequency of 36.7%, 20.5%, 18.2% and 11.6% respectively and calm wave condition of 8.1% (fig. 3a). During NE monsoon period (November, December, January, February) the dominant wave directions were in ENE and E (fig. 3b). During SW monsoon period (June, July, August) the dominant wave directions were in SSE and SE (fig. 3c). And duration and intensity of wave action were dominant in NE monsoon period.

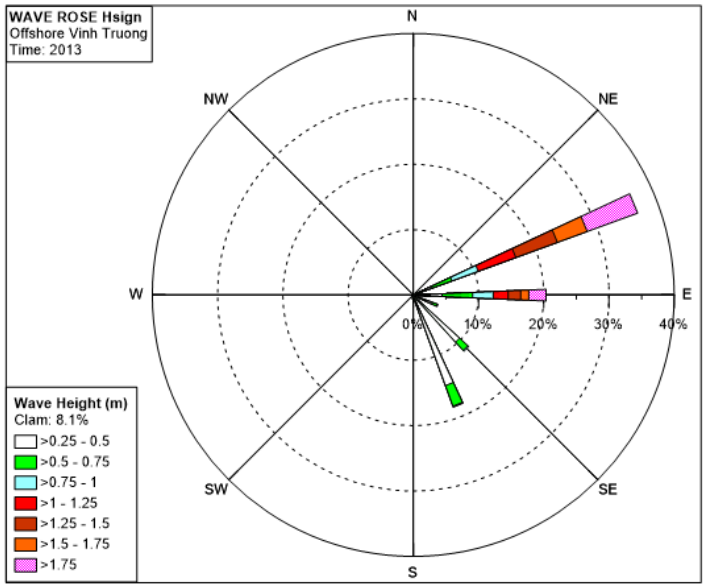

Fig. 3a. Frequency distribution of significant wave height-H_s (m) in 2013

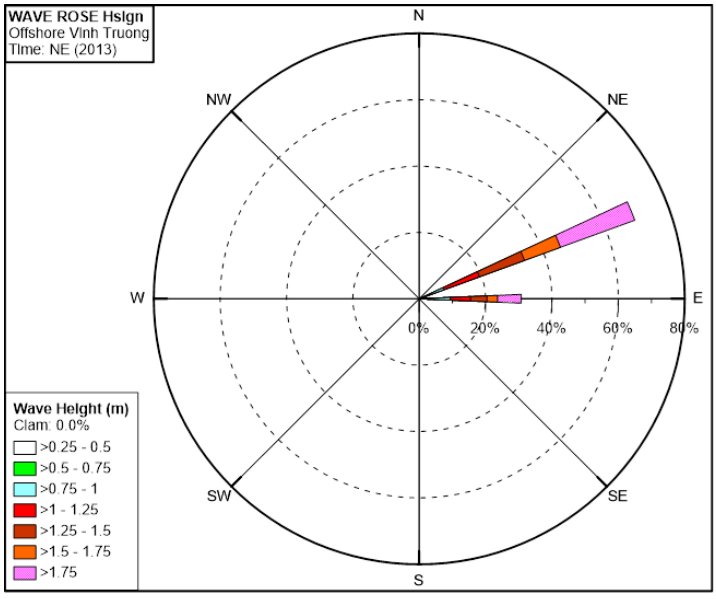

Fig. 3b. Frequency distribution of significant wave height-H_s (m) during NE monsoon period of the year 2013 (November, December, January, February)

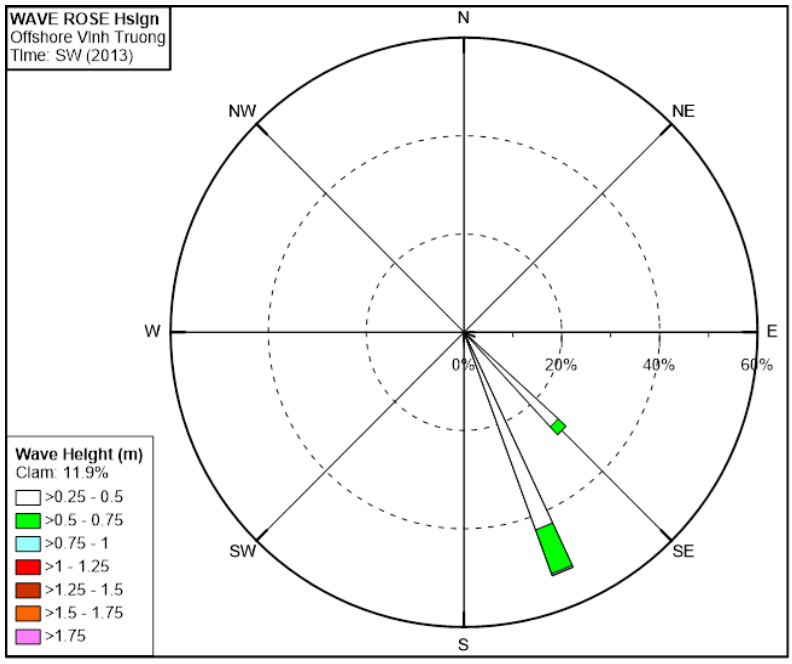

Fig. 3c. Frequency distribution of significant wave height-H_s (m) during SW monsoon period of the year 2013 (June, July, August)

Wind data from fig. 2 and wave data from fig. 3a, 3b, 3c indicate that the study site was less affected by incident wave from SW direction. That means during SW monsoon wave energy in study area was mainly induced by breeze or wave refraction from offshore region.

During 2013 the maximum wave height H_{max}(m) value was 4.84 m in November 2013 and minimum value was 0.18 m in June 2013 (table. 2, fig. 4). The maximum value of H_{max} also occurred during NE monsoon.

Similarly, the monthly distribution of significant wave height H_s(m) shows that the maximum value was 3.24 m in February 2013 and minimum value was 0.12 m in September 2013 (table 3, fig. 5).

Table 2. Monthly distribution of maximum wave height-H_{max}(m) during 2013

Months	Average H_{max}(m)	Max H_{max}(m)	Min H_{max}(m)
January	2.32	4.20	1.02
February	2.13	4.21	0.51
March	1.21	3.97	0.24
April	0.90	2.54	0.24
May	0.60	3.36	0.19
June	0.58	1.55	0.18
July	0.56	1.58	0.21
August	0.62	1.17	0.26
September	0.65	1.94	0.18
October	1.37	4.22	0.45
November	1.89	4.84	0.74
December	2.72	4.63	0.83
Year	**1.29**	**4.84**	**0.18**

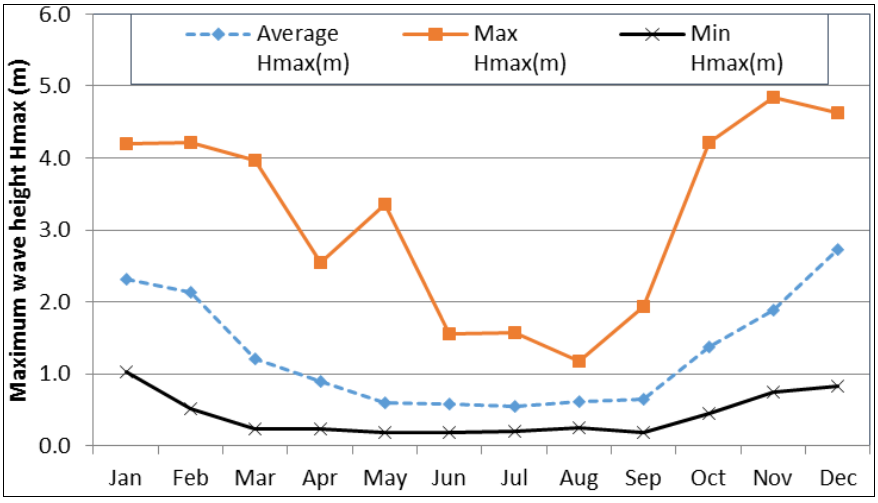

Fig. 4. Diagram of the monthly distribution of maximum wave height-H_{max}(m) during 2013

Table 3. Monthly distribution of significant wave height-H_s(m) during 2013

Months	Average H_s(m)	Max H_s(m)	Min H_s(m)
January	1.53	2.58	0.65
February	1.41	3.24	0.37
March	0.80	2.61	0.19
April	0.60	1.59	0.15
May	0.39	2.01	0.13
June	0.38	1.03	0.14
July	0.37	1.09	0.15
August	0.41	0.73	0.19
September	0.43	1.11	0.12
October	0.92	2.17	0.30
November	1.24	3.23	0.53
December	1.81	2.93	0.60
Year	**0.85**	**3.24**	**0.12**

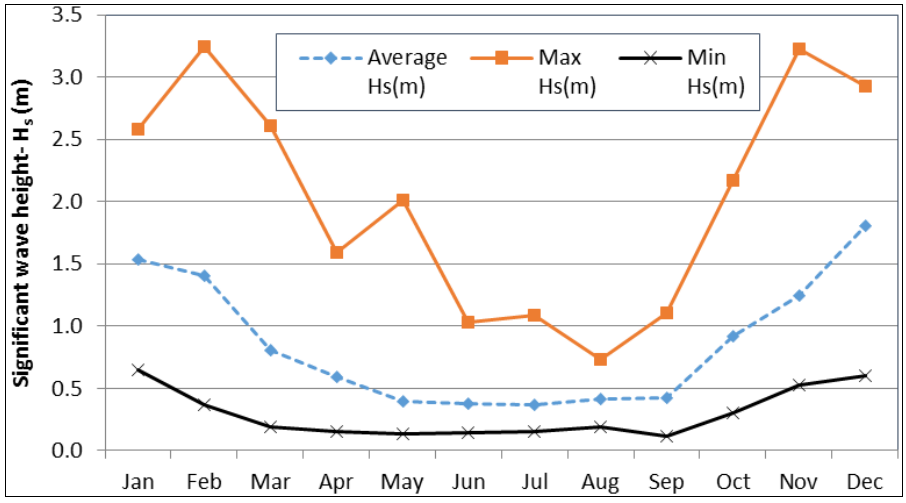

Fig. 5. Diagram of the monthly distribution of significant wave height-H_s(m) during 2013

Monthly distribution of wave period T(s) shows that the maximum value was 10.9 s in November 2013 and minimum value was 1.98 s in April 2013 (table 4, fig. 6). That means during NE monsoon wave period was larger than that of SW monsoon.

Table 4. Monthly distribution of wave period-T(s) during 2013

Months	Average	Max	Min
January	4.67	6.25	2.66
February	4.42	6.17	2.09
March	4.17	7.77	2.34
April	3.68	6.51	1.98
May	3.31	6.34	2.10
June	3.30	5.06	2.01
July	3.37	5.79	2.03
August	3.37	5.28	2.30
September	3.79	7.14	2.01
October	4.53	9.92	2.52
November	4.69	10.90	3.10
December	4.93	6.83	2.97
Year	**4.01**	**10.90**	**1.98**

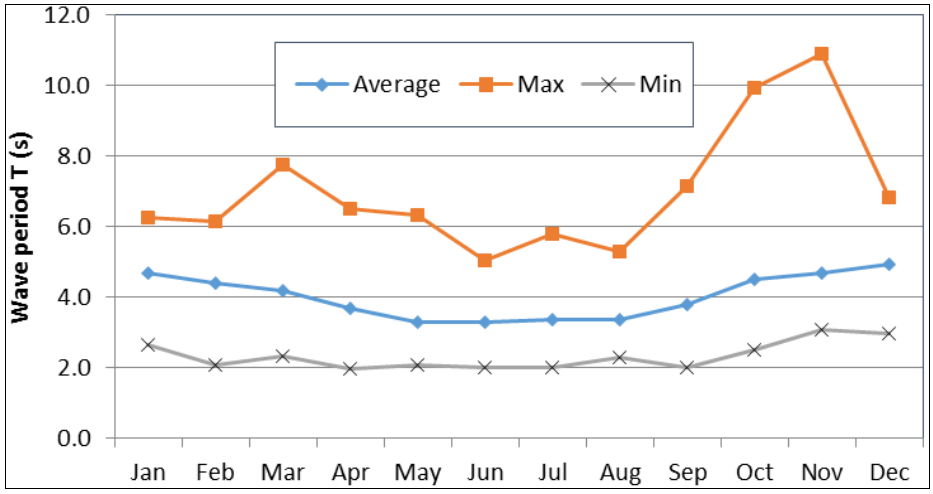

Fig. 6. Diagram of the monthly distribution of wave period-T(s) during 2013

During 2013 the occurrence frequency of $H_s \leq 0.5$ m was 43.9%, $H_s \approx 0.5$–1.0 m was 21.9%, $H_s \approx 0.5$–1.0 m was 21.9%, $H_s \approx 1.0$–2.0 m was 27.3%, $H_s > 2.0$ m was 6.8% and calm wave condition ($H_s \leq 0.25$ m) was 8.1%.

CONCLUSIONS

Ninh Thuan waters has narrow continental shelf and direct interaction with hydro-dynamical processes from open sea such as wind, wave, current, storm-surge... especially during NE monsoon and typhoon activity period.

During 2013 the dominant wave directions were in ENE, E, SSE and SE with occurrence frequency of 36.7%, 20.5%, 18.2% and 11.6% respectively and calm wave condition of 8.1%. During NE monsoon period (November, December, January, February) the dominant wave directions were in ENE and E. During SW monsoon period (June, July, August) the dominant wave directions were in SSE and SE. And duration and intensity of wave action were dominant in NE monsoon and typhoon activity period.

The maximum value of wave height (H_{max}) was 4.84 m (11/2013), that of wave period (T) was 10.9 s (11/2013). The occurrence frequency of $H_s \leq 0.5$ m was 43.9%, $H_s \approx 0.5$–1.0 m was 21.9%, $H_s \approx 0.5$–1.0 m was 21.9%, $H_s \approx 1.0$–2.0 m was 27.3%, and $H_s > 2.0$ m was 6.8%.

The duration and intensity of wave action were dominant in NE monsoon period.

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ĐẶC ĐIỂM PHÂN BỐ CÁC ĐẶC TRƯNG SÓNG TẠI VÙNG BIỂN VEN BỜ TỈNH NINH THUẬN

Lê Đình Mầu, Nguyễn Văn Tuân

Viện Hải dương học, Viện Hàn lâm Khoa học và Công nghệ Việt Nam, Việt Nam

Tóm tắt. Bài báo trình bày đặc điểm phân bố các đặc trưng sóng từ chuỗi số liệu sóng tự ghi liên tục với tần suất 1 giờ/lần từ tháng 1 đến tháng 12 năm 2013 tại vùng biển ven bờ tỉnh Ninh Thuận. Kết quả phân tích, thống kê cho thấy hướng sóng chủ đạo là đông-đông bắc, đông, nam-đông nam và đông nam với tần suất xuất hiện tương ứng là 36,7%, 20,5%, 18,2% và 11,6%. Thời kỳ gió mùa Đông Bắc hướng sóng chủ đạo là đông-đông bắc và đông. Thời kỳ gió mùa Tây Nam hướng sóng chủ đạo là nam-đông nam và đông nam. Các hướng còn lại có tần suất xuất hiện không đáng kể. Độ cao sóng (H_{max}) lớn nhất là 4,84 m (11/2013), chu kỳ sóng lớn nhất là 10,9 s (11/2013). Tần suất xuất hiện của độ cao sóng hữu hiệu $H_s \leq 0,5$ m là 43,9%, $H_s \approx 0,5$–1,0 m là 21,9%, $H_s \approx 0,5$–1,0 m là 21,9%, $H_s \approx 1,0$–2,0m là 27,3%, $H_s > 2,0$ m là 6,8% và lặng sóng ($H_s < 0,25$ m) là 8,1%. Thời gian và cường độ tác động của sóng chiếm ưu thế trong thời kỳ gió mùa Đông Bắc.

Từ khóa: Độ cao sóng hữu hiệu (H_s), độ cao sóng cực đại (H_{max}), Ninh Thuận, gió mùa, dải ven biển.