



Macao Beach Water Quality Monitoring Report 2020



**Laboratory Division of
Municipal Affairs Bureau**

Table of Contents

I.	Introduction.....	2
1.	Beach Water Quality Monitoring Programme	3
2.	Assessment of Beach Water Quality	4
3.	Rainfall Effect on Beach Water Quality	5
4.	Summary of Annual Beach Water Quality	5
II.	Monitoring Results of Bacteriological Parameters	6
1.	Bacteriological Parameters	6
2.	Bacteriological Ranking of Water Quality	7
III.	Monitoring Results of Physical and Chemical Parameters.....	8
1.	Physical Parameters	8
2.	Organic Pollution Parameters	8
3.	Nutrient Pollution Parameters	9
4.	Heavy Metal Pollution Parameters.....	10
5.	Eutrophication Index	11
6.	Comprehensive Assessment of Water Quality.....	12
IV.	Monitoring Results of Biological Parameters.....	13
1.	Algae.....	13
2.	Other Creatures.....	13
V.	Summary.....	14

I. Introduction

To safeguard the health of swimmers and understand the long-term water quality of beaches, the Laboratory Division of the Municipal Affairs Bureau (IAM) of Macao carries out regular monitoring of the water quality of the two public beaches in Macao, namely Hac Sá Beach and Cheoc Van Beach.



With smooth sand and gentle slope, Hac Sá Beach is an ideal place for strolling and playing in the water.



Cheoc Van Beach has white sand and vast coast, making it good for leisure and relaxation.

1. Beach Water Quality Monitoring Programme

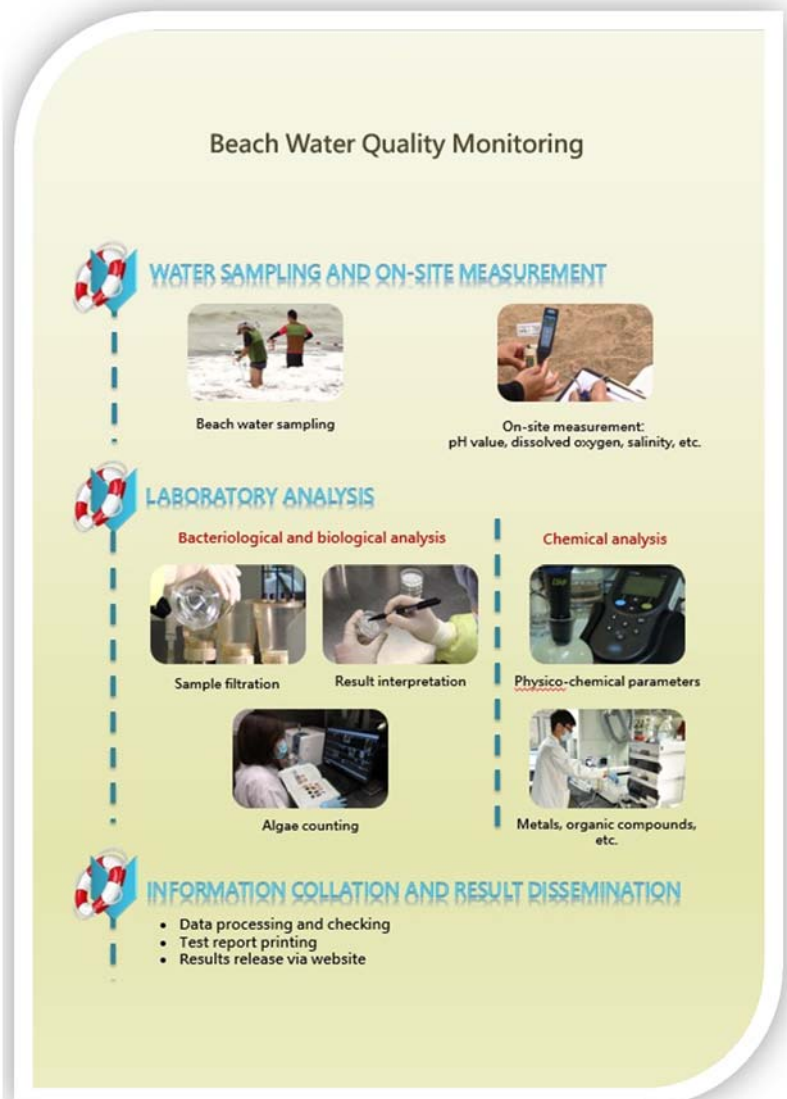
The three water quality monitoring points at Hac Sá Beach are located in the waters facing the three lifeguard stands respectively, while the two monitoring points at Cheoc Van Beach are located close to the two sides of the rope net in the swimming area.



The three monitoring points at Hac Sá Beach



The two monitoring points at Cheoc Van Beach



Upon arrival at the beaches, the sample collectors first observe and pay attention to the environment on site, such as weather changes and state of the sea, including the appearance of red tide and creatures like jellyfish. After carrying out on-site tests of pH value, dissolved oxygen and others, the sample collectors send the samples to the laboratory, which are subject to testing of multiple bacteriological, physical and chemical or biological parameters each time in accordance with the monitoring programme.

In view of the large number of users of the beaches during the swimming season (from May to October every year), the monitoring of water quality must be strengthened during the period. Samples are collected once per week during the swimming season and once per month during non-swimming seasons. In 2020, sample collection was carried out 32 times at Hac Sá Beach and 27 times at Cheoc Van Beach. A total of 149 water samples were collected at both beaches and 3,744 tests were conducted for over 40 parameters.


2. Assessment of Beach Water Quality

The beach water quality is assessed on the basis of the geometric mean of *Escherichia coli* (*E. coli*) counts in the five most recent water samples. When the mean count of *E. coli* in the five most recent samples exceeds 610 CFU/100 mL (>610 CFU/100mL), or the *E. coli* in the most recent water sample collected exceeds 1600 CFU/100 mL (>1600 CFU/100mL), the beach water quality is assessed as “fail” .

In case of a fail in beach water quality, the relevant government authorities will be notified immediately to facilitate appropriate follow-up.

According to all results of geometric mean of *E. coli*, with reference to the annual ranking system of beach water quality of the Environmental Protection Department of Hong Kong which classifies beach water quality into four ranks, namely “Good” , “Fair” , “Poor” and “Very Poor” , assessment on the annual conditions of

Annual Ranking System of Beach Water Quality	
Rank	<i>E. coli</i> count per 100mL
Good	≤24
Fair	25 - 180
Poor	181 - 610
Very poor	> 610



water quality of beaches and provision of information about long-term trends of beach water quality can be made.

3. Rainfall Effect on Beach Water Quality

The beach water quality can deteriorate rapidly during or after heavy rain, and it usually resumes normal in around three days. Therefore, swimming in beaches should be avoided as far as possible during heavy rain or within three days thereafter.

4. Summary of Annual Beach Water Quality

This report makes a summary and overall assessment of the water quality of the two beaches in Macao on the basis of monitoring results of the major parameters. The bases of assessment are as follows:

- Bacteriological parameters – With reference to the standards of beach water quality of the Environmental Protection Department of Hong Kong.
- Physical and chemical parameters – With reference to the “Sea Water Quality Standard” (GB3097-1997) Class II water: applicable to aquaculture zones, bathing beaches, water sports or recreational areas with direct human contact with sea water.

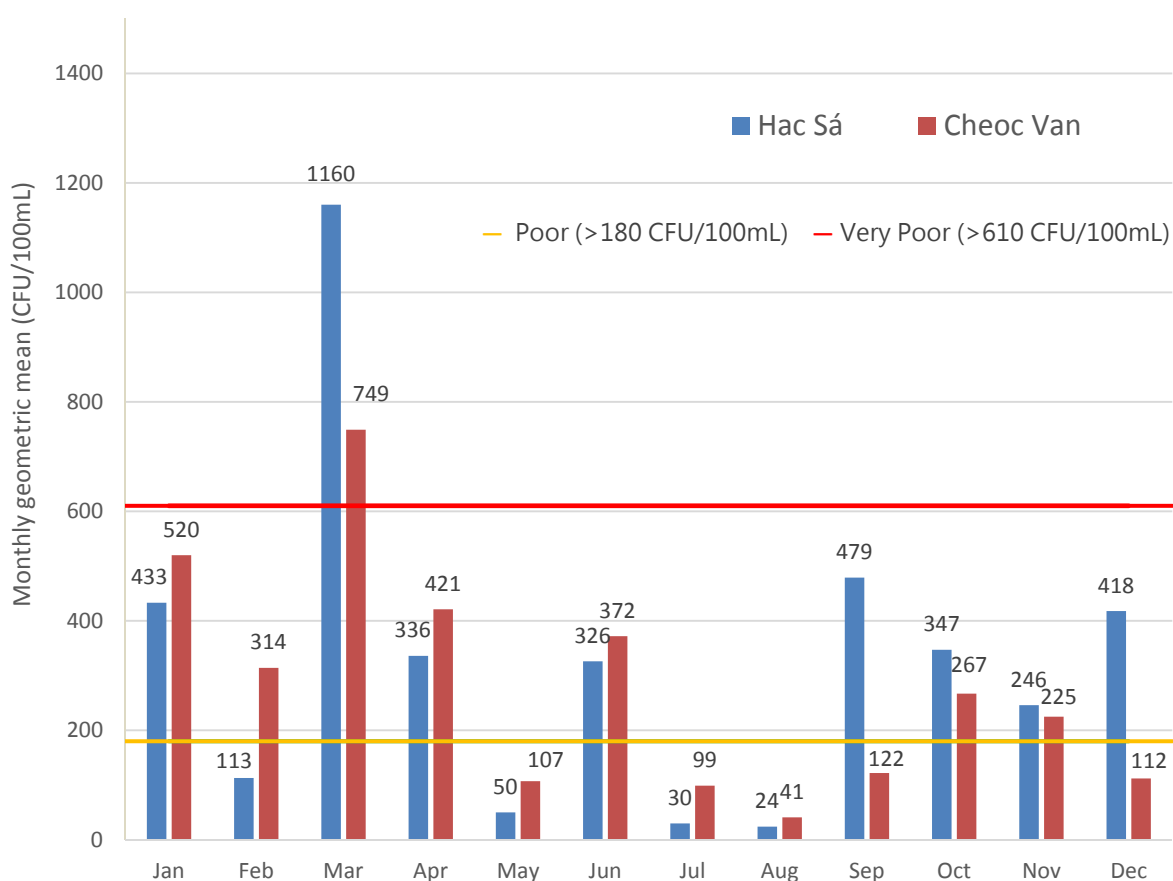
II. Monitoring Results of Bacteriological Parameters

1. Bacteriological Parameters

The bacteriological monitoring items include *Escherichia coli* (*E. coli*) and *Vibrio cholera* (serogroups O1 and O139).

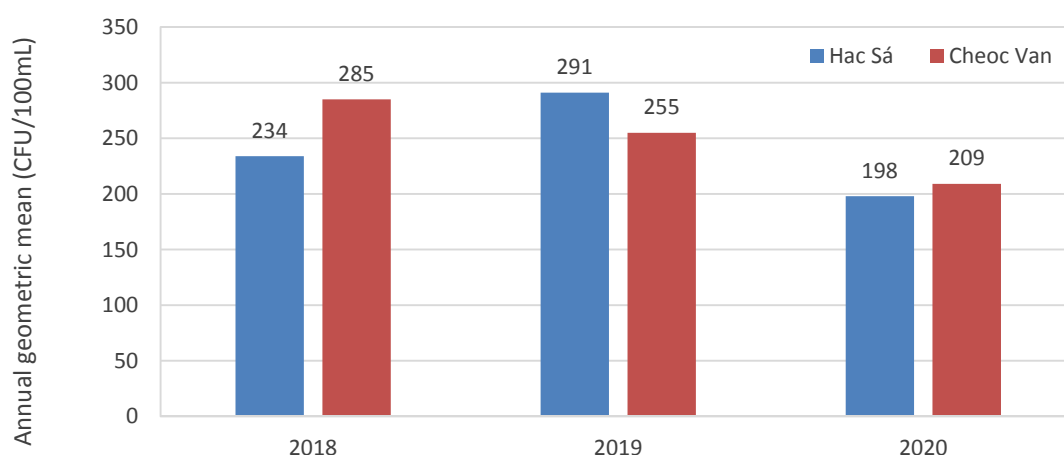
(1) *Escherichia coli* (*E. coli*)

The monthly geometric means of *E. coli* of March were the highest throughout the year, resulting in 1160 CFU/100mL (Hac Sá Beach) and 749 CFU/100mL (Cheoc Van Beach). In August, the monthly geometric means of *E. coli* detected were 24 CFU/100mL (Hac Sá Beach) and 41 CFU/100mL (Cheoc Van Beach), being the lowest in the year.



Monthly geometric mean of *Escherichia coli* in 2020

Samples were collected from Hac Sá Beach for a total of 32 times in the whole year and the number of failed water quality was 9, resulting in a passing rate of 71.9%. Samples were collected from Cheoc Van Beach for 27 times in total throughout the year and the number of failed water quality was 3, resulting in a passing rate of 88.9%. The annual geometric means of *E. coli* were lower than those of the previous two years.



Annual geometric means of *Escherichia coli* of the two beaches from 2018 to 2020

(2) *Vibrio cholera* (serogroups O1 and O139)

Vibrio cholera (serogroups O1 and O139) was not detected at the two beaches this year.

2. Bacteriological Ranking of Water Quality

On the basis of *E. coli* test results and with reference to the beach ranking system of the Environmental Protection Department of Hong Kong, it can be seen that the water quality of the majority of the swimming season was ranked "Poor". In particular, the water quality standards of Hac Sá Beach and Cheoc Van Beach in March reached the "Very Poor" rank. There were three months and five months respectively that the water quality was ranked "Fair" in Hac Sá Beach and Cheoc Van Beach. The water quality of Hac Sá Beach achieved the "Good" rank in August.

III. Monitoring Results of Physical and Chemical Parameters

The monitoring items of physical and chemical parameters include physical parameters, organic pollution parameters, nutrient pollution parameters and heavy metal pollution parameters, while the eutrophication index and the comprehensive water quality assessment index are also calculated.

1. Physical Parameters

Physical parameters (water temperature, conductivity, salinity, turbidity and pH value):

- The water temperature was between 17.1°C and 32.3°C.
- The conductivity was between 4.3 mS/cm and 42.5 mS/cm, and the salinity was between 1.8 psu and 29.6 psu. The results of both parameters were relatively dispersed. The mean values of conductivity and salinity showed significant increase which was estimated to be related to low rainfall.
- Turbidity is the most direct factor affecting the senses of beach users. The annual turbidity means of Hac Sá Beach and Cheoc Van Beach were 72 NTU and 61 NTU respectively, both lower than those of 2019. Moreover, a downward trend was observed for three consecutive years since 2018. Turbidity is mainly determined by the comparatively large suspended substances in beach water.
- Some pH value results exceeded the “Sea Water Quality Standard” for Class II (7.8 – 8.5). Both beaches recorded 13 results lower than 7.8 in January, April to August, October and December. It is estimated that the increase in upstream water brought a large amount of organic matters to the waters near the two beaches, resulting in a decrease in pH value of water.

2. Organic Pollution Parameters

The organic pollution parameters include dissolved oxygen, permanganate index (chemical oxygen demand) and five-day biochemical oxygen demand. They are all important indicators of the severity of organic pollution of the water and its ability to achieve self-cleaning effect through self-oxidation process.

- The dissolved oxygen of the two beaches maintained at high levels and all the results reached the “Sea Water Quality Standard” for Class II (>5 mg/L).
- The permanganate index (chemical oxygen demand) basically reached the “Sea Water Quality Standard” for Class II (≤ 3 mg/L). From May to August, the permanganate index of Hac Sá Beach and Cheoc Van Beach exceeded 3 mg/L for three times and twice respectively. The mean values of the results of the two beaches were 2.05 mg/L (Hac Sá Beach) and 2.02 mg/L (Cheoc Van Beach) respectively, representing a slight increase compared to the results of 1.99 mg/L (Hac Sá Beach) and 1.79 mg/L (Cheoc Van Beach) in 2019.
- Five-day biochemical oxygen demand: Two test results of Cheoc Van Beach exceeded the “Sea Water Quality Standard” for Class II (≤ 3 mg/L). All other test results of the two beaches were lower than the “Sea Water Quality Standard”. Among them, the test results of Hac Sá Beach in August and those of Cheoc Van Beach in May and August were higher than the limit of detection (< 2 mg/L) of the analysis method. The results indicated that the level of organic pollution was higher in the water of Cheoc Van Beach than in that of Hac Sá Beach.

3. Nutrient Pollution Parameters

The nutrient pollution parameters include unionised ammonia, inorganic nitrogen and reactive phosphate.

- The test results of unionised ammonia of the two beaches did not exceed the “Sea Water Quality Standard” for Class II (≤ 0.020 mg/L). The mean values of Hac Sá Beach and Cheoc Van Beach were 0.011 mg/L and 0.009 mg/L respectively in 2019, while those of 2020 were 0.008 mg/L and 0.006 mg/L respectively. On the whole, the test results of the two beaches slightly decreased compared to those of 2019.
- The components of inorganic nitrogen include ammonium nitrogen and total oxidised nitrogen. Due to the high dissolved oxygen content in the water of the two beaches which favoured the nitrification process of nitrogen pollutants in water, the inorganic nitrogen was mainly composed of total oxidised nitrogen. The

mean values of the results of the two beaches were 1.12 mg/L (Hac Sá Beach) and 1.15 mg/L (Cheoc Van Beach), a slight decrease compared to the results of 1.32 mg/L (Hac Sá Beach) and 1.36 mg/L (Cheoc Van Beach) in 2019. However, the annual results of inorganic nitrogen continued to exceed the “Sea Water Quality Standard” for Class II (≤ 0.30 mg/L).

- 62% of the results of reactive phosphate of the two beaches exceeded the “Sea Water Quality Standard” for Class II (≤ 0.030 mg/L), representing a slight decrease compared to the results of 2019 (76%). The results ranged between 0.018 mg/L and 0.065 mg/L. Although the reactive phosphate results were an improvement on those of 2019, the water quality was still subject to phosphorus pollution most of the time. Data revealed that the level of pollution was especially higher in non-swimming seasons than in swimming seasons.

4. Heavy Metal Pollution Parameters

The heavy metal pollution parameters include arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc, a total of nine items. The test results showed that all results of heavy metals, except for lead, reached the “Sea Water Quality Standard” for Class II. The water quality of the two beaches was not subject to severe heavy metal pollution and was comparable to that of 2019. In 2019, there were three occasions when individual results of lead tests of Hac Sá Beach exceeded the “Sea Water Quality Standard” for Class II, whereas there was one lead test result of Hac Sá Beach and Cheoc Van Beach that exceeded the standard in 2020. However, some copper test results of Cheoc Van Beach were higher than the limit of detection (<0.0020 mg/L) of the analysis method, accounting for 58% of the test results of the year, showing an increase compared to the 25% of 2019. The following table shows the mean values of results of various heavy metals in 2020 for comparison.

Table 4.1 Comparison Table of Mean Values of Various Heavy Metal Pollution Parameters

Parameter (limit)	Cheoc Van Beach		Hac Sá Beach	
	2019	2020	2019	2020
Arsenic (≤ 0.030 mg/L)	<0.0020	<0.0020	<0.0020	<0.0020
Cadmium (≤ 0.005 mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Chromium (≤ 0.10 mg/L)	<0.0020	<0.0020	<0.0020	<0.0020
Copper (≤ 0.010 mg/L)	<0.0020	0.0021	<0.0020	<0.0020
Mercury (≤ 0.0002 mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Nickel (≤ 0.010 mg/L)	<0.0020	<0.0020	<0.0020	<0.0020
Lead (≤ 0.005 mg/L)	<0.0020	<0.0020	<0.0020	<0.0020
Selenium (≤ 0.020 mg/L)	<0.010	<0.010	<0.010	<0.010
Zinc (≤ 0.050 mg/L)	<0.020	<0.020	<0.020	<0.020

5. Eutrophication Index

The eutrophication index is used for evaluation of the degree of eutrophication of the sea. As a reference indicator of organic and nutrient pollution of sea water, it is calculated by permanganate index (chemical oxygen demand), inorganic nitrogen concentration and reactive phosphate concentration. The larger the index, the more severe is the eutrophication of the water.

As the test results of permanganate index slightly increased and those of both inorganic nitrogen and reactive phosphate slightly reduced, the eutrophication index was comparable to that of 2019. It can be seen from the test results that the eutrophication index of Hac Sá Beach and Cheoc Van Beach ranged from 3 to 45 with the annual mean values at 16 and 18 respectively, similar to the annual mean values (both 18) of 2019. The test results indicated that the nearby water was still subject to pollution caused by excessive nitrogen, phosphorus and other nutrients. The eutrophication index belonged to severe eutrophication.

6. Comprehensive Assessment of Water Quality

The comprehensive assessment of water quality is made by statistical analysis of the 16 classification indicators of the “Sea Water Quality Standard”, and it is a comprehensive embodiment of the annual water quality of the two beaches. In order to differentiate the impacts of non-metal and metal pollutants on the beach water quality, the comprehensive assessment is divided into non-metal assessment (7 classification indicators: pH value, dissolved oxygen, permanganate index, biochemical oxygen demand, unionised ammonia, inorganic nitrogen and reactive phosphate), metal assessment (9 classification indicators: arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc) and overall physical and chemical assessment (16 classification indicators). The two beaches were mainly subject to non-metal pollution including nutrient pollution and trace metal pollution.

- Non-metal assessment: It was in the critical region (>0.9) from 2016 to 2020. In spite of a slight decrease in the test results of inorganic nitrogen and reactive phosphate of the two beaches in 2020, there was a slight increase in the permanganate index, resulting in a non-metal assessment index similar to that of 2019. The non-metal assessment indexes of Hac Sá Beach and Cheoc Van Beach were both 1.00, showing the unfavourable conditions of the non-metal assessment of the two beaches.
- Metal assessment: The metal assessment indexes of Hac Sá Beach and Cheoc Van Beach were both 0.10. Among them, the metal assessment index of Hac Sá Beach was comparable to that of 2019. 50% of copper test results of Cheoc Van Beach were higher than the limit of detection (<0.0020 mg/L) of the analysis method, resulting in a higher metal assessment index than that of 2019, but the content maintained at a very low level. Furthermore, trace metals, such as arsenic, nickel, iron and manganese, were detected in both beaches, but the content was at relatively low levels.
- Overall physical and chemical assessment: As the metal assessment index of Cheoc Van Beach was higher than that of 2019, there was an increase in the overall assessment index. The overall assessment index of Hac Sá Beach did not vary greatly compared to that of 2019. Both beaches maintained at medium level for years.

IV. Monitoring Results of Biological Parameters

1. Algae

- Qualitative analysis: The most common dominant algae of the two beaches was similar to that of last year, with skeletonema costatum and chaetoceros as the major types. Among the 24 tests at Hac Sá Beach throughout the year, skeletonema costatum was detected for a total of ten times, being the most frequently occurring algae. The next ones were thalassionema and chaetoceros that were detected for seven times and five times respectively. Among the 23 tests at Cheoc Van Beach throughout the year, skeletonema costatum and chaetoceros were each detected for eight times whereas thalassionema was detected for five times.
- Quantitative analysis: The annual geometric mean of algae at Hac Sá Beach was 180 Natural units/mL, a relatively large decline compared to the mean of 240 Natural units/mL in 2019. The annual geometric mean of algae at Cheoc Van Beach was 190 Natural units/mL, a slight increase compared to the mean of 180 Natural units/mL in 2019. The annual growth trends of algae of the two beaches were similar and the active growing period of algae was from July to August.
- Red tide: No red tide occurred at the two beaches this year.

2. Other Creatures

- On the shore of Cheoc Van Beach, a large jellyfish was found once (6 May) and a small number of dead fish was found once (8 June).

V. Summary

1. Classification was made according to the annual geometric mean values of *E. coli* with reference to the Environmental Protection Department of Hong Kong. The water quality of the two beaches was ranked “Poor” this year.
2. *Vibrio cholera* (serogroups O1 and O139) was not detected at the two beaches.
3. In spite of a slight decrease in the test results of inorganic nitrogen and reactive phosphate, there was a slight increase in the test result of permanganate index, leading to an eutrophication index comparable to that of 2019.
4. The metal assessment index of Cheoc Van Beach was higher than that of 2019, resulting in an increase in overall assessment index. However, the overall physical and chemical index of the two beaches maintained at medium level.
5. Red tide did not occur at the two beaches, and algae grew more actively in summer. The most common dominant algae of the year was *skeletonema costatum* and *chaetoceros*.