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Technical English for Civil Engineering

Interim report

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# ABSTRACT

### Marine water in Hong Kong is an important resource that supports the marine ecosystem and daily life of human beings. However, the pollution due to rapid population growth threatens the coastal waters of Hong Kong. Therefore, the Environmental Protection Department in Hong Kong has put a lot of effort in the pollution control by the implementation of environmental legislation and pollution prevention measures.

### In this study, the marine water quality data from 1995 to 2015 obtained from the Environmental Protection Department were processed and plotted as time series graphs to see the trend change of the water quality. Literature review was conducted to see what are the possible pollution sources and pollutants that may affect the marine water quality in Hong Kong. Four classifications for the overall trend of marine water quality, including “improving”, “deteriorating”, “stable” and “undefined” in different water control zones were defined.

### The results show that marine water quality in Deep Bay and Southern are stable of deteriorating respectively. The overall trend of water quality in Mirs Bay, North Western and Western Buffer are undefined due to the inconsistent trend between the water quality parameters. The marine water quality in Eastern Buffer, Junk Bay, Port Shelter Data, Tolo Harbour and Channel and Victoria Harbour has been improved from 1995 to 2015.

### To conclude, the trend of water quality changes was identified. The reasons for the change of marine water quality in the water control zones will be explained by the end of January 2017. Proposed new schemes in water quality control will be finished on 1st May 2017.

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# INTRODUCTION

## Background

### Hong Kong Special Administrative Region has a land area of 1,106 square kilometers and 1,649 square kilometers of marine water (Environmental Protection Department, 2015, p. 1). According to Census and Statistics Department (2016), more than 7 million people are living in Hong Kong and the population growth rate is 0.8 percent.

### The majority of the population and industrial activities are located along the long coastline as the sea is multipurpose and has high economic values. For instance, seafood production, recreation, navigation and the supply of flushing water are the contributions of marine water. However, serious water pollution problems have developed due to growing population over the past two decades (Environmental Protection Department, n.d.).

## Current Status

### Domestic sewage, industrial wastewater, agricultural runoff and cross-border pollution from Pearl River were the sources of marine water pollutants (Environmental Protection Department, n.d.). These water pollutants had adversely affected the health of our marine water environment. The scenic marine landscape was destroyed and the quality of marine water became not suitable for swimming. Furthermore, the assimilative capacity of marine water was lowered by the disposal of sewage and it may lead to the extinction of marine life (Au, 2005, p. 6).

### In order to protect the valuable marine water, the Government divided Hong Kong waters into 10 Water Control Zones (WCZs) and set the Water Quality Objectives (WQOs) for each WCZ (Hong Kong Water Quality Resource Centre, 2015). Furthermore, the Hong Kong Government expects that the WQOs can be fully achieved by environmental legislation and implementing pollution abatement measures. Additionally, the Environmental Protection Department (EPD) conducted a comprehensive and scientific monitoring programme to measure the marine water quality since 1986 with the aims of protecting the health of Hong Kong’s marine environment and achieving the WQOs (Wong, n.d.). In the interim, Annual Marine Water Quality Report had published according to the results of the monitoring programme.

## Motivation of the Study

### The annual marine water quality reports have been described on the trends of data. However, the reports do not have an appropriate analysis of the reasons why marine water quality has been changing and do not provide the future direction for the improvement of marine water quality. Nevertheless, proper analysis of the changes of marine water quality can permit us to understand what can be done to the marine environment and thus to improve our marine water resources.

## Project Aims

### The aims of this project are:

* + To evaluate the changes of the marine water quality in Hong Kong
  + To identify possible reasons for the changes of water quality
  + To provide recommendations for the improvement of marine water quality

## Scope of Study

### In the study, literature review was performed to analyze the changes of marine water quality for the ten water control zones from 1995 to 2015. The possible reasons for the changes in marine water quality in three selected water control zone will be identified. The effectiveness of existing pollution prevention measures and environmental legislation for the improvement of marine water quality in Hong Kong will be evaluated. At last, recommendations on the future improvement of Hong Kong marine water quality will be given.

## Objectives of this Report

### The objectives of this interim report are:

* + To present the preliminary findings
  + To report the progress
  + To provide the future plan for the study

## Structure of this Report

### This report is structured as follows:

* + Chapter 1 provides the background of the study.
  + Chapter 2 presents the literature review of the study.
  + Chapter 3 describes the methodology of the study.
  + Chapter 4 shows the preliminary findings of the project.
  + Chapter 5 gives the conclusions of the study.
  + Chapter 6 outlines the project schedule of the study.

# MAJOR TYPES OF MARINE POLLUTANTS AND ITS INDICATORS

## Introduction

### Marine water is usually considered as the “ultimate sink” of wastewater and solid waste. Therefore, marine pollutants are introduced into the marine system and these marine pollutants can affect the water quality significantly.

### In this chapter, sources of marine pollution will be introduced. Moreover, the major types of marine pollutants and its indicators presented by the source of marine pollution will be discussed.

## Sources of Marine Pollution

### Marine pollution can mean solid waste such as glass bottles and cans, oil and chemical spills or polluted rivers and stormwater drains flowing into the sea (Ministry for the Environment, 2016). In general, there are two types of marine pollution which are the point source and the non-point source. Furthermore, for the marine pollution, there are four major types of marine pollutants which are suspended particles, pathogens, oxygen demanding organic wastes and nutrients (Ainsley, n.d., p.4).

* + 1. Point Source

### Point source pollution is any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch ship. Sewage disposal and industrial effluent are the major sources of point source pollution (Environment Protection Authority Victoria, 2016).

### The formation of sewage is mainly contributed by municipal wastewater. Municipal wastewater includes domestic wastewater such as wastewater generated from laundries, toilets and kitchens. Moreover, commercial buildings, schools and public activities such as street washing can generate municipal wastewater and this will become sewage eventually. Sewage will then be transferred to sewage treatment plant for different levels of treatment and discharged into the ocean in the end. Suspended solids, biodegradable organics, pathogens and nutrients are common contaminants in sewage.

### Industrial effluents may contain complex organic chemicals such as pharmaceuticals, pesticides and dyes. The effluents may come from electric power plants, food industry or iron and steel industry. Disinfectant, nutrients and endocrine disrupting chemical are common contaminants in industrial effluents.

* + 1. Non-point Source

Non-point source pollution is a pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Non-point source can be divided into source activities related to either land or water use, including failing septic tanks, improper animal-keeping practices and forestry practices. Urban Runoff and agricultural runoff are the major sources of non-point source pollution (Kean University Continuing Education, n.d.).

### Due to urbanization, different kinds of trench drain are developed for surface runoff of rainwater. However, rainwater is always mixed with different kinds of pollutants such as sediments and solids from construction sites and drained into the sea. Therefore, urban runoff becomes one of the major sources of flooding and water pollution in urban communities worldwide. On the other hand, oxygen demanding material, suspended solids, nutrients and pathogens are common marine pollutants in urban runoff.

### Excessive rainfall and Irrigation can lead to agricultural runoff. As pesticides and fertilizer are usually used in agriculture, the agricultural runoff may be polluted and get into the surface water and the groundwater. Finally, the agricultural runoff may pass through the soil or by other means to the ocean. Sediment, pesticides and nutrients are common marine pollutants in agricultural runoff.

### Apart from urban runoff and agricultural runoff, local illegal discharge such as a pig farm in a rural area may be one of the pollution sources. The illegal discharge is hard to trace and contributed load to the marine system (Legislative Council, 2011). Hong Kong is close to the Pearl River Delta. Therefore, the pollutants such as sediment and nutrient from mainland China may receive by Hong Kong marine water (Greenpeace, 2010).

## Suspended Particle and Its Indicators

### Suspended solid is one of the major types of pollutants. In general, suspended solids come from municipal wastewater, agricultural runoff and transboundary pollution from Pearl River. Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solids concentration (Kemker, 2014).

* + 1. Turbidity

### The physical mixing of suspended solids and marine water can give an important indication of water quality which is the turbidity. Turbidity is a measure of water clarity by optical determination and it is the most visible indicators of water quality. It describes the amount of light scattered or blocked by suspended particles in a water sample (Alaska Department of Environmental Conservation, 2013). Water with high turbidity will appear cloudy, murky, or otherwise colored, affecting the physical look of the water (Kemker, 2014).

### Adverse effects may result in high turbidity on the marine water system. High turbidity means more suspended solids in the water and the suspended solids tend to absorb heat and thus to decrease the dissolved oxygen of marine water (Kemker, 2014). Furthermore, high content of suspended solid may block the sun and restrict the photosynthesis production of underwater vegetation. Therefore, the dissolved oxygen may further have lowered and the marine species such as fish may be affected without sufficient supply of oxygen (Winter, Chaloub & Durate, 2016).

## Pathogens and Its Indicators

### Pathogens are disease-causing microorganisms and it is mainly generated from human and animal wastes. Bacteria and viruses are the main pathogens. These microorganisms are transported into the coastal waters by the discharge of domestic wastewater and storm runoff (Pandey, 2014). The discharge point of sewage usually has higher content in E. coli. As pathogen may cause disease, Escherichia coli bacteria (E. coli) is used to indicate the levels of pathogens in water resources (Ferguson, 2012).

* + 1. E. coli

### E. coli normally lives in the intestines of warm-blooded organisms. Most E. coli are harmless and actually are an important part of a healthy human intestinal tract. However, some E. coli are pathogenic and they can cause serious illness such as food poisoning (World Health Organization, 2016).

### On the other hand, one of the E. coli, O157:H7 can cause diarrhea and this E. coli can transfer through contaminated water or food through contact with animals or persons (Centers for Disease Control and Prevention, 2016). As Pathogen can affect the human health seriously and the E. coli can indicate the levels of pathogens. Therefore, E. coli is selected to be one of the key parameters in this study. Furthermore, the presence and number of E. coli can be determined by Laboratory tests (AACC, 2016).

## Oxygen Demanding Organic Wastes and Its Indicators

### Oxygen demanding organic wastes are commonly found in sewage with wastes or nutrients from human, domestic or wildlife. They consumed dissolved oxygen in the sea and break down the carbon chains in organic compounds into simple inorganic molecules such as carbon dioxides by aerobic decomposition and utilize some of the organic matters for creating new bacterial cells (Buchana & Seabloom, 2004).

### Aerobic decomposition of organic matter due to pollution:

### Organic waste + Bacteria Cells + O2 ➔ CO2 + H2O + more bacteria cells

### The rate of oxygen used in the aerobic reaction is generally faster than the re-aeration from photosynthesis of underwater plants and atmosphere. As a result, depletion of oxygen and suffocation of aquatic life may result. Furthermore, the generated bacteria cells may generate foul odors (APEC WATER, n.d.).

* + 1. BOD5 and DO

### The oxygen required by bacteria to degrade organic pollutants is called BOD. It also indicates the amount of oxygen-consuming organic pollutants. BOD can be measured by BOD test. As the standard oxidation test period for BOD is 5 days at 20 degrees Celsius. The measured value of BOD is called BOD5. It is commonly used to indicate the effects of sewage and other organic wastes on dissolved oxygen in surface water (Delzer & McKenzie, 2003).

### DO is sensitive and it can be affected by air pressure, salinity and temperature (Fundamentals of Environmental Measurements, 2013). The solubility of oxygen decreases as water temperature increases. As a result, the concentration of DO will vary by season. If the concentration of DO decrease, the impact on the marine ecology can be huge. All higher class aquatic life such as fish and shrimp needs DO larger than 4mg/L but the lack of DO can kill them by suffocation (Environment and Natural Resources, n.d.). In general, the concentration of dissolved oxygen is usually an indication of organic pollution.

## Nutrients and Its Indicators

### Nutrients are one of the most common pollutants in marine water. It is because of the excessive discharge of domestic wastewater. In addition, fertilizers used in agricultural activities are rich in total inorganic nitrogen and phosphorous. They are usually washed by excessive rainfall and irrigation to the ocean. Once the nutrients washed into the ocean, the excess nutrients may lead to eutrophication. Eutrophication generally promotes excessive plant growth and decay, favors certain weedy species over others, and is likely to cause severe reductions in water quality (BBC, 2014).

### According to Chislcok (2014), eutrophication can decrease the water transparency, cause dissolved oxygen depletion, increase incidences of fish kills, deteriorate the taste of water and generate an odour of water. It shows that the eutrophication can affect the turbidity, DO and E. coli at the same time. This also implied that all the water parameters are interrelated and the balance between them is important.

* + 1. Total Inorganic Nitrogen (TIN)

### TIN is a measure of the total nitrate, nitrite, and ammonia concentration of a body of water (Babylon, n.d.). All of them are the different forms of nitrogen and they can be used by organisms to synthesize proteins and DNA. On the other hand, aquatic plants need them to grow. TIN is traditionally used to evaluate the water quality and thus it is selected in this project.

# METHODOLOGY

## Introduction

### In this chapter, the source of data, definition of change and the classification are included. Moreover, the methodology including the selection of pollution Indicators, selection of water control zones for case study and statistical techniques applied are introduced for the analysis of marine water quality in Hong Kong.

## Data Description

### In this report, all the marine water monitoring data used will be obtained from the 20 years Marine Water Quality Reports in Hong Kong published by EPD. From the 76 marine monitoring stations, a range of physical, chemical and biological parameters, including temperature, pH, dissolved oxygen and unionized ammonia nitrogen can be measured (EPD, 2015).

### Five parameters were chosen in this project, including Turbidity, Total Inorganic Nitrogen (TIN), E. coli bacteria (E. coli), Dissolved Oxygen (DO) and 5-day Biochemical Oxygen Demand (BOD5).

## Selection of Pollution Indicators

### EPD has calculated an overall compliance rate that is based on the combined individual compliance rates of all monitoring stations for four important key parameters (TIN, E. coli, DO and Unionized Ammonia Nitrogen) to evaluate the change of marine water quality (EPD, 2015, p. 4).

### TIN, E. coli and DO are selected and studied as they are key parameters in WCZs. Unionized Ammonia Nitrogen will not be studied as it is positively correlated with TIN. Turbidity is selected as it can be observed by unaided eye easily and it is always concerned by the general public. Furthermore, BOD5 is selected because it influences the concentration of DO in water effectively.

### To conclude, the individual trend of change from 1995 to 2015 of five water pollution indicators (also known as water quality parameters) in the 10 WCZs, including Turbidity[NTU], TIN[mg/L], E. coli[cfu/100mL], DO[mg/L], BOD5[mg/L], will be studied. To be convenient, only the surface water quality will be analyzed.

## Selection of Water Control Zone for Case Study

### Some of the WCZs have similar trends on change of the pollution indicators and the results cannot draw a valuable conclusion for the improvement of marine water quality in the future. Therefore, three Water Control Zone, where represent the case of improving, deteriorating and steady marine water quality respectively, will be selected for more detailed analysis.

## Statistical Techniques Applied

### In order to understand the trends of change of the pollution indicators from 1995 to 2015, statistical techniques will be applied in the study. Basic statistics and time series plots will be used in this paper.

### From basic statistics, the maximum, minimum and mean of the marine water quality data are calculated to provide a baseline for analysis.

### For time series plots, these plots can be used to obtain the trends of change of the pollution indicators in the study period (Anderson, 1995). The steps for establishing a time series plot are shown in the below example.

### Worked example

### There are five monitoring stations named as DM1 to DM5 in Deep Bay. According to EPD Marine Water Quality Data (2016), the average DO in surface water for each monitoring station in 2015 are listed in Table 1.

Table 1: DO concentration in Deep Bay,2015

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Station** | **Mean DO in surface water(mg/L)** | **Annual mean (mg/L)** |
| 2015 | DM1 | 4.5 | 5.4 |
| DM2 | 5.1 |
| DM3 | 5.5 |
| DM4 | 5.9 |
| DM5 | 6.2 |

Annual mean = 5.4mg/L

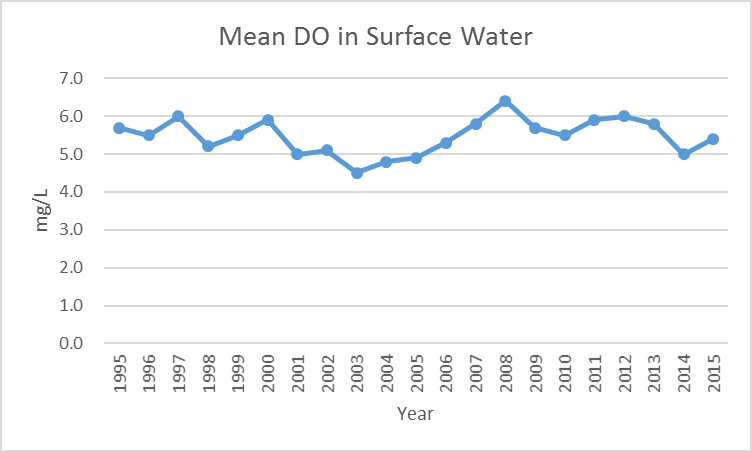


Figure 1: Mean DO in surface water

### From table 1, the annual mean of DO concentration in Deep Bay is calculated as 5.4mg/L. By performing the same calculation for the following years, the annual means of DO from 1995 to 2015 can be calculated and the results can be used to plot against year. Hence, a time series plot of mean DO concentration in Deep Bay from 1995 to 2015 can be plotted as seen in Figure 1.

## Definitions of the Change

### In the report, the change of the pollutant indicators can be observed from the time series plot. However, the changes are vague as the fluctuation among the data is large. As a result, an analysis of the trends (trend change method) for the pollution indicators is defined for studying the change of marine water quality in the ten WCZs. The trends of the pollution indicators basically refer to the overall tendency of the time series plot.

### For “Increasing trend”, it refers to a positive slope on the time series plot and vice versa. “No significant change” refers to a zero slope on the time series plot.

### In table 2, how the trends of change for different time series plots of the pollution indicators from 1994 to 2003 are shown.

Table 2: Illustration of the Trend Change Method

|  |  |
| --- | --- |
| **Worked Example** | |
|  |  |
| **Increasing Trend** | **Decreasing Trend** |
|  | |
| **No significant change** | |

## Definitions of the Classification

### In order to describe the overall change of marine water quality in the past two decades, three categories are used to classify the change in the five pollution indicators for each WCZ.

The definitions of the classification are stated as below:

* + “Improving” means that turbidity, E-coli, BOD5 and TIN have a decreasing trend while DO has an increasing trend.
  + “Deteriorating” means that turbidity, E-coli, BOD5 and TIN have an increasing trend while DO has a decreasing trend.
  + “Stable” means all the pollution indicators have no significant change and the overall water quality is moderate from 1995 to 2015.

Table : Definitions of the Classification

|  |  |  |
| --- | --- | --- |
| **Classification** | **Pollution Indicators** | **The Trend Change** |
| **Improving** | Turbidity | Decreasing Trend |
| E-coli |
| BOD5 |
| TIN |
| DO | Increasing Trend |
| **Deteriorating** | Turbidity | Increasing Trend |
| E-coli |
| BOD5 |
| TIN |
| DO | Decreasing Trend |
| **Stable** | Turbidity | No Significant Change |
| E-coli |
| BOD5 |
| TIN |
| DO |

# Preliminary findings

## Results

### In order to study the trend change of the five selected water quality parameters, the data of water quality parameters in the 10 water control zone were downloaded from the website of Environmental Protection Department. Excel was used to process the data and graphs are plotted to observe the trend change of the water quality parameters in the 10 water control zone. The results are shown in the table below.

Table : Summary Table for the trend change of all WCZs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **WCZ** | **Turbidity**  **(NTU)** | **DO**  **(mg/L)** | **BOD5**  **(mg/L)** | **E-coli**  **(cfu/100mL)** | **TIN**  **(mg/L)** | **Overall**  **Trend** |
| **Deep Bay** | **↗** | **➙** | **➙** | **↗** | **➙** | **Stable** |
| Eastern Buffer | **↗** | **↗** | **↘** | **↗** | **↗** | **Improving** |
| Junk Bay | **↗** | **↗** | **↘** | **↗** | **↗** | **Improving** |
| Mirs Bay | **↗** | **➙** | **➙** | **↗** | **↘** | **Undefined** |
| North Western | **↗** | **➙** | **➙** | **↗** | **↘** | **Undefined** |
| Port Shelter Data | **↗** | **➙** | **↗** | **↗** | **↘** | **Improving** |
| **Southern** | **↗** | **➙** | **↘** | **↘** | **↘** | **Deteriorating** |
| Tolo Harbour and Channel | **↗** | **↘** | **↗** | **↗** | **↗** | **Improving** |
| **Victoria Harbour** | **↗** | **↗** | **↗** | **↗** | **➙** | **Improving** |
| Western Buffer | **↗** | **➙** | **➙** | **↗** | **↘** | **Undefined** |

### There are 3 symbols used in table 4. **↗, ➙** and **↘** mean improving, stable and deteriorating respectively. Based on the trend change of the five water parameters, the overall trend of the water quality in the water control zones can be classified. However, the overall trend of the water quality in Junk Bay, North Western and Western Buffer cannot be defined. It is because the overall trend of marine water quality is determined by the water quality parameters with the same trend for three times or more.

Three water control zones are boldfaced, including Deep Bay, Southern and Victoria Harbour, in the table as they are typical and representing the overall trend, stable, deteriorating and improving respectively. It is believed that the future water quality control schemes can be investigated by studying the three selected water control zones.

## Difficulties and Limitations

### The data of marine water quality from the Environmental Protection Department is reliable. However, the data may not be suitable to use for identifying the water quality changes in Hong Kong. This is because the water control zones are not fully covered by the stations for sample collection so that the actual water quality changes may not be recorded. In other words, the sample size may not be large enough to reflect the real situation.

# Conclusion

### This research contributed to the development of the new water quality control schemes. The changes of the marine water quality in Hong Kong were evaluated. Moreover, the possible reasons for the changes of marine water quality were identified. Recommendations for the improvement of marine water quality will be given after locating all the key reasons for the changes of water quality in the final report.

### The study including the identification of the changes in the marine water quality in Hong Kong was conducted. The results showed that the marine water quality in the 10 water control zones in Hong Kong was generally improved from 1995 to 2015. Four classifications for the overall trend of water quality were defined, including “improving”, “deteriorating”, “stable” and “undefined”. Water quality in Deep Bay is stable. The overall trend of water quality in Mirs Bay, North Western and Western Buffer were undefined. Eastern Buffer, Junk Bay, Port Shelter Data, Tolo Harbour and Channel and Victoria Harbour showed the improving trend. However, the water quality in Southern was deteriorating.

### Current research on marine water quality are concentrated on how the water quality changes instead of giving reasons for the changes. Proper analysis of the changes of marine water quality including the identification of pollution sources could permit us to understand what can be done to the marine environment and thus to improve our marine water resources.

### In this study, the major limitation is the data for the analysis of marine water quality. The data may not be sufficient to show the real trend of the water quality in a water control zone as the data used may not be representative of the water quality as a whole of the water control zone.

### Although the water quality in the 10 water control zones was improving, the water quality in Southern was deteriorating. Therefore, the government should pay more attention to controlling and managing the water quality by implementing water quality control schemes such as Harbour Area Treatment Schemes.

# Project Schedule

## Introduction

### The Study commenced on 01 September 2016 and it will end on 05 May 2017. A comprehensive programme for the Study including all Milestones, deliverables and the corresponding dates was attached in the Appendix.

### The programme is prepared by using “GanttProject” and it will be updated as necessary during the course of the Study.

## Current Situation

### With reference to the study programme in Appendix, the inception report was finished on time. The data and methodology were assembled in an early stage. Literature reviews were completed and the trend changes of the five selected marine water quality parameters over the past two decades were identified in this report.

### The original plan on the interim report is to include the study of why marine water quality has been changed in past twenty years. However, the huge volumes of data about the selected water quality parameters are difficult to handle and extra time is needed. Therefore, the reasons for the changes of marine water quality such as the implementation of water quality control policies will be finished on 27th January 2017.

## Future Plan

### According to the study programme attached in Appendix, the interim presentation is set on 18th January 2017. My school exam will end on 22nd December 2016 and five days are expected for the preparation of interim presentation. Therefore, I will prepare my presentation materials and powerpoint for the presentation from 13th January 2017 to 17th January 2017.

### Apart from the interim presentation, the possible reasons for the changes of marine water quality in the past two decades will be studied on 10th November 2016 and the implementation of water quality control schemes will be introduced in this section right after the identification of the trend change of marine water quality. Furthermore, two months will be used to evaluate the effectiveness of existing water quality control policies and scheme.

### In addition, a chapter about recommendations for the future development of water quality control will be provided in the final report. New schemes in water quality control will be suggested in the chapter of recommendations and this chapter will be finished on 1st May 2017 with reference to current water quality control measures. It is expected that the final report can be finished on 5th May 2017.

### The final oral presentation is set on 8th March 2017 which is before the due date of the final report and the chapter of recommendations. Therefore, the recommendations for the future development of water quality control may not be presented. Moreover, a week should be reserved for the preparation of final oral presentation.

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# Appendix

