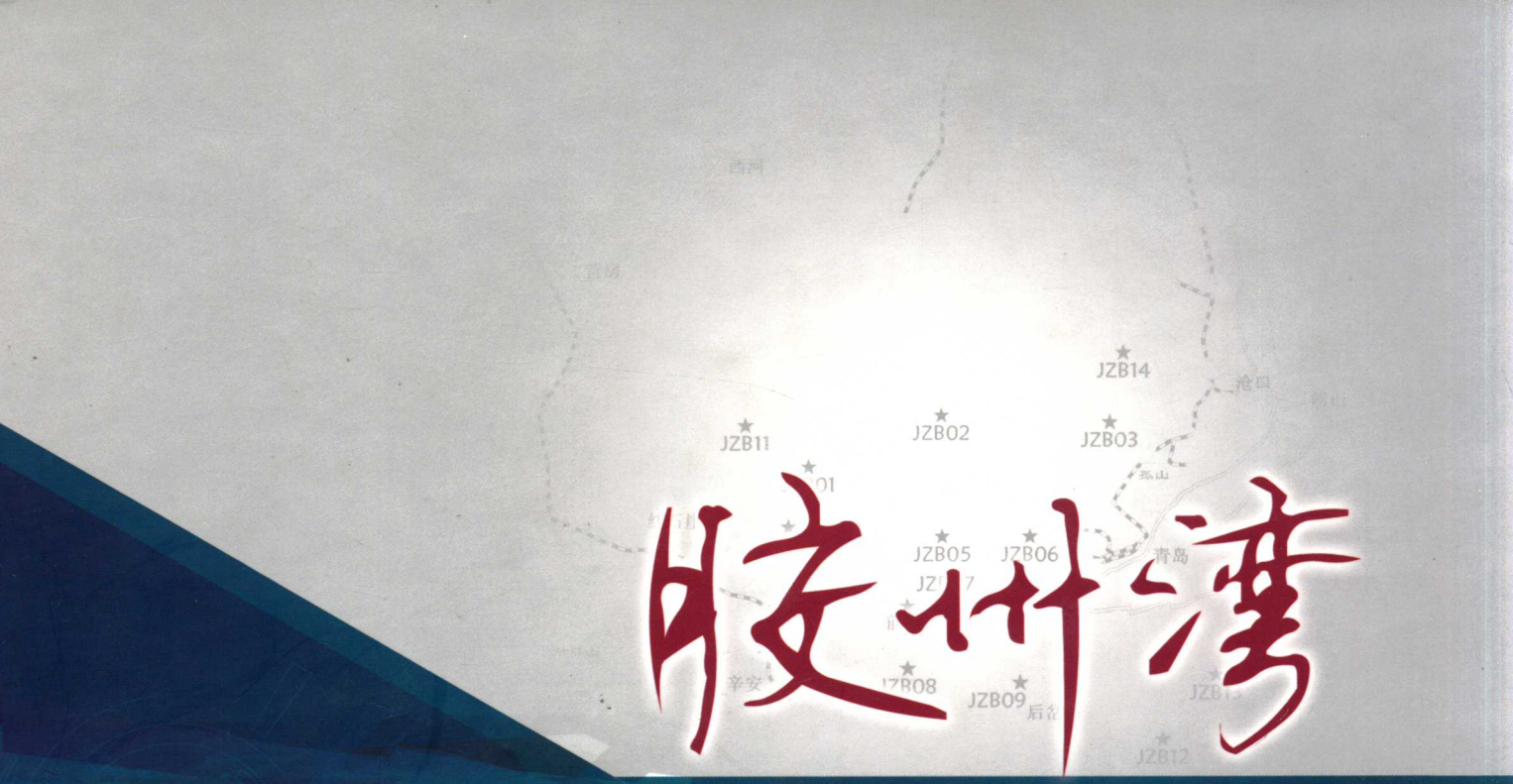

胶州湾

生态系统长期变化图集

ATLAS OF LONG-TERM CHANGES IN THE JIAOZHOU BAY ECOSYSTEM

（下册）

孙 松 孙晓霞 主编

海洋出版社

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2011年·北京

内容简介

本图集是胶州湾生态系统国家野外科学观测研究站近十年来对胶州湾生态系统进行长期、综合观测研究的成果。全书涵盖了胶州湾物理海洋学、化学海洋学、生物海洋学、悬浮体与沉积物等不同要素、不同季节的水平分布图，以更加直观的方式，反映胶州湾生态系统主要要素的长期变化。本图集不仅为胶州湾生态系统长期变化研究、海洋生态系统健康评估、海洋生态环境保护、海洋经济可持续发展提供基础资料和决策依据，同时也为从事海洋科学、生态科学以及全球变化领域研究的科技人员、管理人员以及其他有关人员系统了解胶州湾生态系统状况提供参考。

Introduction

This atlas was created based on long-term, comprehensive observations and research conducted by the Jiaozhou Bay Marine Ecosystem Research Station over the past decade. The book covers the distribution of different ecological elements in four seasons, including physical oceanography, chemical oceanography, biological oceanography, suspended matter and sediments in Jiaozhou Bay. The information is presented in an intuitive way, reflecting the long term changes in the major elements of the Jiaozhou Bay ecosystem. It is anticipated that this atlas will provide basic data that can be used for decision-making regarding the Jiaozhou Bay ecosystem, as well as studies investigating long term changes, marine ecosystem health assessment, marine environment protection and sustainable development of the marine economy of the bay. Additionally, the atlas will help individuals conducting research in the marine science, ecological science and global change fields understand the status of the Jiaozhou Bay ecosystem.

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胶州湾生态系统长期变化图集

Atlas of Long－Term Changes in the Jiaozhou Bay Ecosystem

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Atlas of Long-Term Changes
in the Jiaozhou Bay Ecosystem

胶州湾生态系统长期变化图集

>> 序

在地球科学研究领域，“全球变化”和“生态系统”是人们提及最多的两个词。从过程和机理上了解全球变化和人类活动对生态系统的影响是地球科学研究领域的一个重要的热点问题。海洋是地球系统的重要组成部分，是全球气候和环境变化的主要驱动力。如何科学地认知在全球自然变化和人类活动双重影响下海洋生态系统的演变过程与机制、预测其变化趋势，并在此基础上建立基于生态系统的管理体制，实现海洋资源与环境的可持续发展，是一个非常重要的科学问题，也是一个社会和经济发展中必须解决的问题。在海洋生态系统长期变化研究中，核心问题是能否获得长期的观测资料。由于海洋的特殊性和复杂性，对海洋生态系统进行长期观测是非常困难的，因此如何共享这些来之不易的现场观测资料，让其最大限度地发挥作用显得十分重要。

在我国的海洋生态系统研究中，胶州湾生态系统占有重要地位。胶州湾是一个集港口、旅游、工业、城市建设、海水养殖、海洋工程等为一体的典型海湾，不仅受到自然变化的影响，更重要的是受到人类活动的影响，是我国沿海发展的生态系统变化的一个缩影，在国内和国际上均具有很好的代表性。开展对胶州湾生态系统的研究，是揭示人类活动和全球变化对近海生态系统影响的一个理想区域。胶州湾海洋生态系统国家野外科学观测研究站在胶州湾及其邻近海域生态系统综合调查和观测方面积累了丰富的数据和资料，对近海生态系统动力学研究和生物资源与生态环境的可持续发展研究具有重要的意义。

《胶州湾生态系统长期变化图集》是在近十几年来对胶州湾生态系统进行长期综合观测的基础上，对胶州湾生态系统的现状及长期变化规律的一个全面展示，是第一部系统、直观反应胶州湾生态系统各要素长期变化情况的图书。该书的出版，将为近海生态系统的长期变化研究、以生态系统为基础的管理与保护提供重要的科学与决策依据，同时也为今后深入了解和掌握全球变化影响下近海生态系统的变动规律和内在机制奠定良好的基础。

2011年4月于北京

>> Preface

In the field of Earth Science, "global change" and "ecosystem" are commonly mentioned. There is currently a great deal of interest in the effects of global change and human activities on ecosystems. As an important part of the global ecosystem, the ocean is the main force driving global climate and environmental change. Accordingly, understanding how evolution, mechanisms and trends in the marine ecosystem are influenced by natural processes and human activities is important to establishment of ecosystem based management and realization of the sustainable development of marine resources, as well as to addressing social and economic development. One of the core issues in the study of long-term changes in the marine ecosystem is the availability of long-term observational data. Because of the particularity and complexity of the ocean, it is very difficult to conduct long-term observations of marine ecosystems. Therefore, it is very important to share observation data and maximize its roles.

The Jiaozhou Bay ecosystem plays an important role in Chinese marine ecosystem research. Jiaozhou Bay is a typical bay serving ports, tourism, industry, urban construction, aquaculture and marine engineering. The bay is not only influenced by natural changes, but also human activities, acting as a miniature model of Chinese coastal ecosystem change. Additionally, the bay is a good representative of coastal ecosystem both domestically and internationally. Jiaozhou Bay is an ideal area to reveal the impacts of human activities and global change on coastal ecosystems. Jiaozhou Bay marine ecosystem research station has accumulated a wealth of data and information based on comprehensive observations. The data generated by the station have had a large impact on studies of the dynamics of coastal ecosystems, biological resources and sustainable development of the ecological environment.

"Atlas of Long-Term Changes in the Jiaozhou Bay Ecosystem" is a comprehensive display of the status and long term patterns of the Jiaozhou Bay ecosystem based on long-term comprehensive observations over the past decade. This atlas is the first book to reflect the long-term changes in various elements in the Jiaozhou Bay ecosystem directly and systematically. The publication of this book will provide an important scientific and decision-making basis for long term research of coastal ecosystems and ecosystem-based management and protection. The atlas will also provide a good foundation for further understanding of the changes in the marine ecosystem and its internal mechanism.

April 2011, Beijing

>> 前言

海洋在人类经济、社会发展中占有越来越重要的地位。向海洋进军、开发海洋资源、拓展生存空间、发展海洋经济，是我国的重要战略，也是蓝色经济区建设的核心内容。

随着海洋经济的发展，大量人口向沿海地带聚集，沿海的工业化、城镇化建设、海洋岸线的开发、大量工业污水和生活污水的排放、陆源物质的排放、港口建设、跨海大桥的建设、填海、大量的养殖活动等对海洋生态系统、特别是近海生态系统造成了严重的影响。如何实现协调、可持续发展是摆在我们面前的十分艰巨的任务。

维护生态系统健康、海洋生物资源可持续利用、海洋环境可持续发展是实现海洋经济战略的必经之路。要做到这一切的首要任务是加深对海洋生态系统演变规律的研究，了解海洋中已经发生了哪些变化、现在正在发生什么变化，更重要的是预测未来会发生什么样的变化。对海洋生态系统长期变化的研究关键是相关信息的获取，因此海洋长期观测是十分必要的。由于海洋观测非常昂贵，如何实现已有数据和资料的共享显得非常重要。让已经获取的数据和资料充分发挥作用，让所有海洋科技工作者、学生和社会各界都能够方便地使用这些资料是大家共同的愿望。

海湾生态系统是与人类活动关系最密切的生态系统。以胶州湾为例，这里是青岛市的母亲湾，是一个集港口、工业、农业、海水养殖业、滨海旅游业于一体的我国东部发达地区的典型海湾。胶州湾生态系统不仅受到自然气候变化的影响，更受到人类活动的影响。对胶州湾生态系统的研究，是开展人类活动和自然变化双重作用下海洋生态系统演变机理研究的理想场所，也是我国海湾生态系统中开展研究最多的区域。

胶州湾海洋生态系统研究站始建于1981年，原名为黄岛海水养殖试验场。1986年改名为黄岛增养殖实验站。中国生态系统研究网络（CERN）组建后，

本站1991年成为CERN 29个野外观测基本站之一，改名为“胶州湾海洋生态系统研究站”，是我国温带海域唯一的集监测、研究与示范为一体的综合性生态系统研究站。2005年被科技部批准成为国家生态系统野外科学观测研究站，正式命名为“山东胶州湾海洋生态系统国家野外科学观测研究站”。胶州湾站是“中国生态系统研究网络”（CERN）中唯一一个温带海域长期研究站，也是中国科学院海洋基地建设的一个组成部分。

建站之初，胶州湾站主要从事鱼、虾、贝工厂化育苗和高产养殖关键技术的研究、示范工作。出色地完成了“胶州湾海洋环境及资源调查和鱼虾种苗放流增殖实验”等一系列重大项目，我国海洋水产养殖中三次浪潮（海带养殖、对虾养殖和扇贝养殖）的兴起主要始于胶州湾。20世纪90年代以后，胶州湾站针对日渐突出的环境问题，开始对生态系统的结构与功能进行综合调查和长期监测。进入21世纪以来，胶州湾站开始从全球变化和人类活动影响的高度全面考量生态系统的动态变化，研究人与自然和谐发展的途径与关键技术。胶州湾站拥有超过20年的长期时间序列、综合观测数据，收集了100年的气象资料、50年的长期考察资料和生物样品。2003年开始，将监测频率增加到每月1次，长期观测站位14个，基本涵盖了胶州湾主要生态区域。

该图集是在胶州湾生态系统长期变化数据集的基础上完成的，以更加直观的方式，反映胶州湾生态系统主要要素的长期变化，所有数据均是胶州湾生态系统研究站和中国科学院海洋研究所相关人员在胶州湾进行现场考察获取的。希望该图集能够为胶州湾生态系统长期变化研究、海洋生态系统健康评估、海洋生态环境保护、海洋经济可持续发展提供基础资料和决策依据。

该图集是在一系列国家科研项目的资助下完成的，包括中国生态系统研究网络、中国科学院知识创新工程重要方向项目（KZCX2-YW-Q07-01，KZCX3-SW-214）、科技部国家科技基础条件平台建设项目生态系统网络的联网观测研究及数据共享系统建设、“973”项目（2011CB403601，2006CB400606）、国家自然科学基金项目（40631008，40876083）等。在此感谢中国科学院、国家科技部、国家自然科学基金委员会、青岛市和中国科学院海洋研究所给予经费上的支持，感谢所有参与胶州湾生态系统观测的科学家和技术人员，特别感谢中国科学院海洋研究所“科交二号”和“创新号”科学考察船的全体船员对胶州湾长期观测的支持，感谢胶州湾海洋生态系统研究站的各位科技人员的不懈努力，感谢中国科学院海洋研究所各位参与胶州湾生态系统研究和观测的科技工作者。

2011年2月于青岛

>> FOREWORD

The ocean plays an increasingly important role in economic and social development. Developing marine resources, expanding living space, and developing the marine economy is not only an important strategy in China, but is also the core of the construction of the blue economic zone.

Development of the marine economy results in large numbers of people gathering in coastal areas. The marine ecosystem, especially the coastal ecosystem, has been heavily influenced by an abundance of human activities, including industrialization, urbanization, development of the coastline, discharge of industrial effluent, domestic sewage and land-source pollution, harbor construction, bridge construction, reclamation, and aquaculture. Accordingly, determining methods to achieve coordinated, sustainable development is difficult.

Maintenance of ecosystem health, sustainable use of marine living resources, and sustainable development of the marine environment is the only way to realize a marine economic strategy. To achieve this goal, it is important to understand the evolution of the marine ecosystem, e.g., what changes have taken place, what happens now, and more importantly, what will happen in the future. To understand the long-term changes in the marine ecosystem, it is necessary to obtain relevant information; therefore, long-term ocean observations are essential. Because ocean observation is very expensive, it is important to share existing data and information. It is our common wish to share these data and information so that all marine scientists, students and the relevant community have easy access to this information.

Bay ecosystems are closely related to human activities. For example, Jiaozhou Bay is known as the mother bay of Qingdao. This bay combines ports, industry, agriculture, aquaculture and coastal tourism, acting as a typical bay in an eastern developed area. The Jiaozhou Bay ecosystem is not only influenced by natural climate change, but also by human activities. The bay is an ideal place to investigate the evolution of a marine ecosystem impacted by both human activities and natural changes. Accordingly, the Jiaozhou Bay ecosystem is also one of the most-studied bay ecosystems.

Jiaozhou Bay Marine Ecosystem Research Station, which was founded in 1981, was formerly known as the Huangdao testing ground for marine aquaculture. The name was changed to Huangdao Maricultural Experiment Station in 1986. After the Chinese Ecosystem Research Network (CERN) was established, the station became one of the 29 basic stations for field observations and was renamed

the Jiaozhou Bay Marine Ecosystem Research Station. This facility is the only comprehensive ecosystem research station in temperate waters, and it integrates monitoring, research and demonstration. The facility was approved by the Ministry of Science and Technology as a national observation station in 2005, at which time it was officially named the National Research Station of Jiaozhou Bay Marine Ecosystem, Shandong. Jiaozhou Bay station is the only long-term research station in the Chinese Ecosystem Research Network (CERN) that is located in temperate waters, and is also a component of the marine base construction of the Chinese Academy of Sciences.

When the station was first established, the research and demonstrations mainly focused on industrialized breeding and developing methods of high yield aquaculture of fish, shrimp and shellfish. A series of major projects have been completed at the station, including the Jiaozhou Bay marine environment and resources investigation and testing of the reproduction and release of fish and shrimp seed. The three waves of marine aquaculture in China (seaweed, shrimp and scallop culture) began in Jiaozhou Bay. Owing to the increasing environmental problems in the bay, the members of the Jiaozhou Bay station started a comprehensive survey and long term monitoring of the ecosystem structure and function during the 1990s. In the 21st century, the members of Jiaozhou Bay station fully considered the dynamic changes in the ecosystem by combining the multiple influences of global change and human activities to study approaches and key technologies designed to enable the harmonious development of humans and nature. Jiaozhou Bay station has more than 20 years of long term data series, comprehensive observation data, over 100 years of meteorological data, and 50 years of long-term study data and biological samples. Since 2003, the observation frequency has increased to once a month on the 14 long-term observation stations covering the major ecological regions of Jiaozhou Bay.

The atlas was generated based on the dataset of the long-term changes in the Jiaozhou Bay ecosystem. It reflects the long term changes in the major elements of the ecosystem in an intuitive manner. All data were obtained in situ by staff from the Jiaozhou Bay Station and the Institute of Oceanology, Chinese Academy of Sciences. We hope that this atlas provides fundamental data and a decision-making basis for research into long term changes in the Jiaozhou Bay ecosystem, marine ecosystem health assessment, marine environment protection, and sustainable development of the marine economy.

The atlas was funded by a series of research grants, including those from the Chinese Ecosystem Research Network, the Knowledge Innovation Program of the Chinese Academy of Sciences (KZCX2-YW-Q07-01, KZCX3-SW-214), the Infrastructure Project of Ecosystem Network Observation and the data-sharing system of the Ministry of Science and Technology, 973 projects (2011CB403601, 2006CB400606), and the National Natural Science Foundation of China (40631008, 40876083). We appreciate the financial support provided by the Chinese Academy of Sciences, Ministry of Science and Technology, National Natural Science Foundation of China, Qingdao Municipal Science and Technology Commission, and Institute of Oceanology of the Chinese Academy of Sciences. Additionally, we thank all of the scientists and the technical staff involved in the Jiaozhou Bay ecosystem observations, especially the crew of the "Kejiao 2" and the "Innovation" research vessels for their support during the long-term observation of Jiaozhou Bay. We also appreciate the tireless efforts of the staff of the Jiaozhou Bay station as well as our colleagues at the Institute of Oceanology, Chinese Academy of Sciences for their participation in Jiaozhou Bay ecosystem research and observations.

February 2011, Qingdao

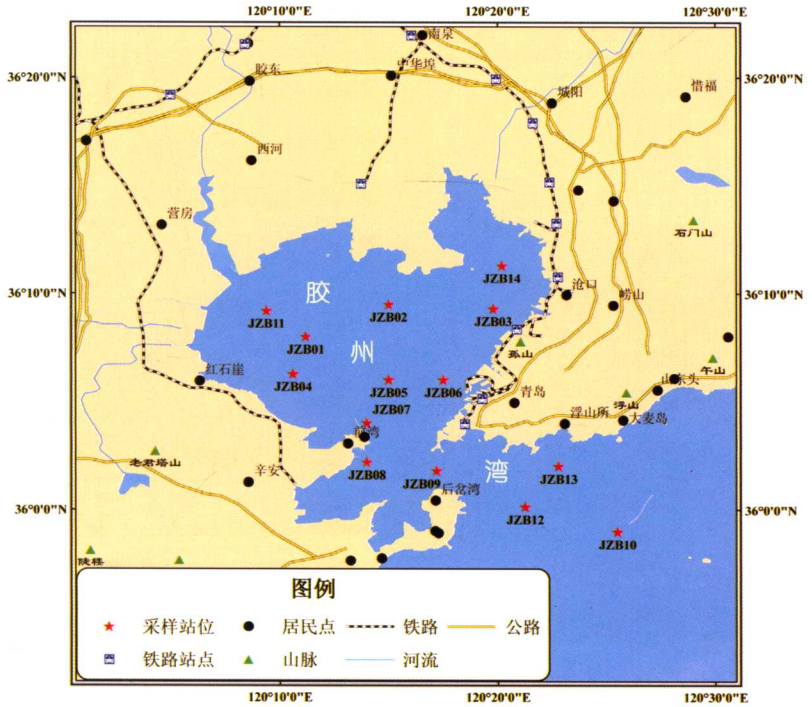
TECHNICAL SPECIFICATION

胶州湾生态系统长期变化图集

>> 技术说明

本图集是在胶州湾海洋生态系统国家野外科学观测研究站对胶州湾生态系统长期观测与研究的基础上完成的。观测内容包括物理海洋学、化学海洋学、生物海洋学、海洋地质等不同领域。本图集主要选取1997－2009年间季度月（即2月、5月、8月和11月中旬）的系统调查数据，对表层的监测要素进行插值绘图。

胶州湾常规调查采用“科交二号”和“创新号”调查船，目前常规调查站位14个，调查监测项目50余项。其中，浮游动物和浮游植物分别使用浅水Ⅰ型、浅Ⅱ型和浅水Ⅲ型浮游生物网进行由底至表垂直拖网采样，样品立即用5%的甲醛海水溶液固定、保存。底栖生物使用0.1m^{2}的大洋50型采泥器，每航次每站成功取样2次作为一个泥样，将泥样经0.5mm孔径过滤筛冲洗掉泥沙，过滤出底栖生物样品，将样品保存于标本瓶中，以75%酒精固定。其他监测要素根据实测水深分层取样，采样水层与采样量根据国家海洋监测规范执行。监测分析项目水温、盐度、水色、透明度等物理海洋学要素采用现场观测记录，其他海洋化学、海洋生物等样品带回室内处理后进行分析。分析方法分别参照海洋调查规范和海洋监测规范执行。



胶州湾调查站位图

Atlas of Long-Term Changes in the Jiaozhou Bay Ecosystem

胶州湾观测样品分析方法

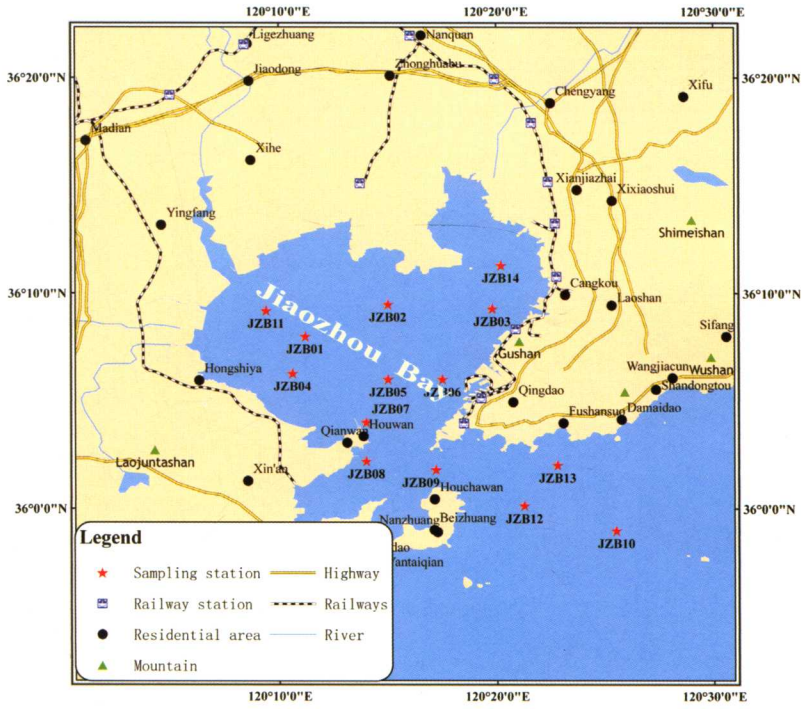
分析项目	分析方法	参照国标
沉积物含水率	重量法	海洋监测规范GB 17378.5–1998
沉积物总磷	磷钒钼黄比色法	海洋调查规范(GB/T 13909 – 1992)
沉积物总氮	元素分析仪法	海洋调查规范(GB/T 12763.8–2007)
沉积物砂土百分含量	Cilas 940L型激光粒度仪	海洋调查规范(GB/T 13909–1992)
沉积物粉砂百分含量	Cilas 940L型激光粒度仪	海洋调查规范(GB/T 13909–1992)
沉积物黏土百分含量	Cilas 940L型激光粒度仪	海洋调查规范(GB/T 13909–1992)
溶解氧	碘量法	海洋监测规范 GB 17378.4–1998
pH	pH 计法	海洋监测规范 GB 17378.4–1998
硅酸盐	硅钼蓝法	海洋监测规范 GB 17378.4–1998
磷酸盐	磷钼蓝法	海洋监测规范 GB 17378.4–1998
亚硝酸盐	重氮–偶氮法	海洋调查规范(GB/T 12763.4–1991)
硝酸盐	铜镉还原柱法	海洋监测规范 GB 17378.4–1998
铵盐	靛酚蓝法	海洋监测规范 GB 17378.4–1998
溶解有机碳	高温燃烧法	国家标准 GB 13191–1991
化学需氧量	碱性高锰酸钾法	海洋监测规范 GB 17378.4–1998
总磷	碱性过硫酸钾氧化法	国家标准 GB 11893–1989
总氮	碱性过硫酸钾氧化法	国家标准 GB 11894–1989
水温	CTD	海洋调查规范(GB/T 12763.2–1991)
盐度	CTD	海洋调查规范(GB/T 12763.2–1991)
悬浮体	重量法	海洋监测规范 GB 17378.4–1998
透明度	目视法	海洋监测规范 GB 17378.4–1998
叶绿素a浓度	荧光分光光度法	海洋监测规范 GB 17378.7–1998
肠道菌数	发酵法	海洋监测规范 GB 17378.7–1998
细菌总数	荧光显微镜直接计数法	海洋监测规范 GB 17378.7–1998
浮游植物细胞数量	浓缩计数法	海洋监测规范 GB 17378.7–1998
浮游动物丰度	计数法	海洋监测规范 GB 17378.7–1998
浮游动物生物量	称重法	海洋监测规范 GB 17378.7–1998
底栖生物密度	计数法	海洋监测规范 GB 17378.7–1998
底栖生物生物量	称重法	海洋监测规范 GB 17378.7–1998

Atlas of Long – Term Changes in the Jiaozhou Bay Ecosystem

>> Technical Specification

The atlas was produced based on the long term observation data of the Jiaozhou Bay ecosystem. The observed parameters included physical, chemical, biological, and geological elements. The monitoring data for the surface layer, obtained quarterly in the middle of February, May, August and November between 1997 and 2009, were used for the interpolation mapping in the atlas.

The research vessels, Kejiao 2 and Innovation, were used for the long term observations in Jiaozhou Bay. More than 50 parameters were monitored at 14 stations. The zooplankton and phytoplankton were sampled by vertical hauling of the plankton net from the bottom to the surface. Three types of plankton nets (PTN-SW1, SW2, SW3) with mesh sizes of 500, 170 and 77 μm, respectively, were used. The samples were preserved with formaldehyde at a final concentration of 5%. The benthos were sampled twice at each station using a 0.1m^2 Ocean 50 dredge, and the samples were washed through a filter sieve with a mesh size of 0.5mm, after which they were preserved with 75% alcohol. The physical parameters, including the seawater temperature, salinity, water color and Secchi depth, were measured in situ. Other marine chemical and biological parameters were determined in the laboratory according to the national standards, the Specification for Marine Monitoring and the Specifications for Oceanographic Survey.



Sampling stations in Jiaozhou Bay

Analysis methods for parameters measured in the survey of Jiaozhou Bay

Parameters	Method	National standard of The Peoples Republic of China
Sediment water content	Gravimetric method	The specification for marine monitoring GB 17378.5–1998
Total phosphorus in sediment	Phosphorus vanadium molybdate yellow colorimetric method	The specification for oceanographic survey (GB/T 13909 – 1992)
Total nitrogen in sediment	Elemental analyzer method	The specification for oceanographic survey (GB/T 12763.8–2007)
Sand content in sediment	Cilas 940L laser particle size analyzer	The specification for oceanographic survey (GB/T 13909–1992)
Silt content in sediment	Cilas 940L laser particle size analyzer	The specification for oceanographic survey (GB/T 13909–1992)
Clay content in sediment	Cilas 940L laser particle size analyzer	The specification for oceanographic survey (GB/T 13909–1992)
Dissolved oxygen	Iodometric method	The specification for marine monitoring GB 17378.4–1998
pH	pH meter	The specification for marine monitoring GB 17378.4–1998
Silicate	Silico–molybdenum blue method	The specification for marine monitoring GB 17378.4–1998
Phosphate	Phosphorus molybdenum blue Method	The specification for marine monitoring GB 17378.4–1998
Nitrite	Diazo–coupling method	The specification for oceanographic survey (GB/T 12763.4–1991)
Nitrate	Cadmium–copper column reduction	The specification for marine monitoring GB 17378.4–1998
Ammonium	Indophenol blue	The specification for marine monitoring GB 17378.4–1998
Dissolved organic carbon	High–temperature combustion method(HTC)	GB 13191–1991
Chemical oxygen demand	Basic potassium permanganate	The specification for marine monitoring GB 17378.4–1998
Total phosphorus	Alkaline potassium persulfate oxidation	GB 11893–1989
Total nitrogen	Alkaline potassium persulfate oxidation	GB 11894–1989
Temperature	CTD	The specification for oceanographic survey (GB/T 12763.2–1991)
Salinity	CTD	The specification for oceanographic survey (GB/T 12763.2–1991)
Suspended matter concentration	Gravimetric method	The specification for marine monitoring GB 17378.4–1998
Secchi disk depth	Visual method	The specification for marine monitoring GB 17378.4–1998
Chlorophyll *a*	Fluorescence spectrophotometry	The specification for marine monitoring GB 17378.7–1998
Intestinal flora	Fermentation	The specification for marine monitoring GB 17378.7–1998
Bacterial abundance	Fluorescence microscope	The specification for marine monitoring GB 17378.7–1998
Cell density of phytoplankton	Microscopic counting method	The specification for marine monitoring GB 17378.7–1998
Abundance of zooplankton	Microscopic counting method	The specification for marine monitoring GB 17378.7–1998
Biomass of zooplankton	Gravimetric method	The specification for marine monitoring GB 17378.7–1998
Density of benthos	Count method	The specification for marine monitoring GB 17378.7–1998
Biomass of benthos	Gravimetric method	The specification for marine monitoring GB 17378.7–1998


胶州湾生态站
青 岛
QING DAO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创新
CHUANGXIN

胶州湾生态系统长期变化图集

（下册）

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