

**Figure 1. All tropical storms recorded from 1956 to 2006.** (Historical monthly data on average precipitation and tropical storms, OCHA-ROAP, 2009. Available from <http://ochoaonline.un.org/roap>. Data from UNISYS)

## Integrated Marine Disaster Risk Management in Xiamen

Xiamen is a port city on China's southeast coast in Fujian Province whose name means "gateway" to the interior land areas. The city gained economic prominence from its coastal location and natural harbor for trade as early as the Song Dynasty (960-1279 AD). The designation of the city as one of China's four experimental Special Economic Zones in 1980, and subsequent open door policy of the country, provided further impetus to an outward and marine economy coupling with construction, reclamation, tourism and other economic activities.

Yet the strategic seaside location is a mixed blessing. The city is subject to frequent storms in spite of the protection provided by the Taiwan Island (**Figure 1**). Extreme weather events, red tides, coastal erosion, siltation (TIO, 1993), fish kills (XDPO, 1998) and other man-made and natural hazards have been intensified by recent climate variations and sea level rise. Engulfed in rapid urbanization and economic growth, Xiamen lacked awareness of the consequences of coastal hazards until the deadly Typhoon No. 9914 hit the city in the year 1999 (**Box 1**).

The huge losses due to Typhoon 9914 triggered substantial efforts by the Xiamen municipal government to create an improved and integrated disaster reduction, preparedness and response system consisting of emergency response plans, institutional arrangements, early warning and forecasting network, and a series of public awareness campaigns.

Integrated coastal management (ICM) was initiated in Xiamen in 1994 with the support of the Global Environment Facility/United Nations Development Programme/International Maritime Organization and PEMSEA. ICM in Xiamen is focused on integration of science into management decisionmaking for sustainable development, improving coordination between various management sectors, public participation, integrated sea-area use

### Box 1. Losses and Damages from Typhoon No. 9914.

The strongest typhoon in terms of rainfall and wind level since 1959 caused, among others:

- Direct economic losses of about 1.938 billion RMB;
- Evacuation of 762,500 people
- Loss of 13 lives, with 3 missing and 727 injuries
- 4,600 houses collapsed and 11,400 houses damaged
- 1,800 hectares of cultivated land and 24,500 hectares of crops damaged
- 5,300 hectares of crops and 623,000 fruit trees destroyed
- 2,166 fishing boats destroyed
- 135,000 m<sup>2</sup> of sheltered dock destroyed
- 22,000 m<sup>2</sup> of seawall destroyed
- 1,800 hectares of shrimp ponds flooded



Global Environment Facility



United Nations Development Programme



United Nations Office for Project Services



Partnerships in Environmental Management for the Seas of East Asia

## Box 2. The History of Xiamen Integrated Marine Risk and Disasters Management.

Before 1980, Xiamen was mainly concerned with city construction and focused on the positive effects of urban development. The government and the public lacked understanding of coastal hazards and its management, including prevention and preparedness. The management of hazards was less developed than the management of economic development. Investments in environmental protection and risk prevention were few and the monitoring system had not yet been established. Lack of coordination between departments often resulted in ineffectiveness, waste of resources, and management confusion when disasters arose.

Starting in 1994, the Xiamen Municipal Government established and implemented integrated coastal management (ICM) with the support of the GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas (the first phase of Partnerships in Environmental Management for the Seas of East Asia or PEMSEA). During this first cycle of implementation of ICM, Xiamen strengthened the integration of science into management decisionmaking, improved

coordination between various management sectors, facilitated public participation, and integrated sea-area use management and law enforcement.

Though natural and man-made hazards were identified during profiling and strategy development, hazard management still lacked a powerful commanding system so it could not effectively focus resources spread out over various sectors in a timely manner during times of disaster.

### Alarm from Typhoon No. 9914

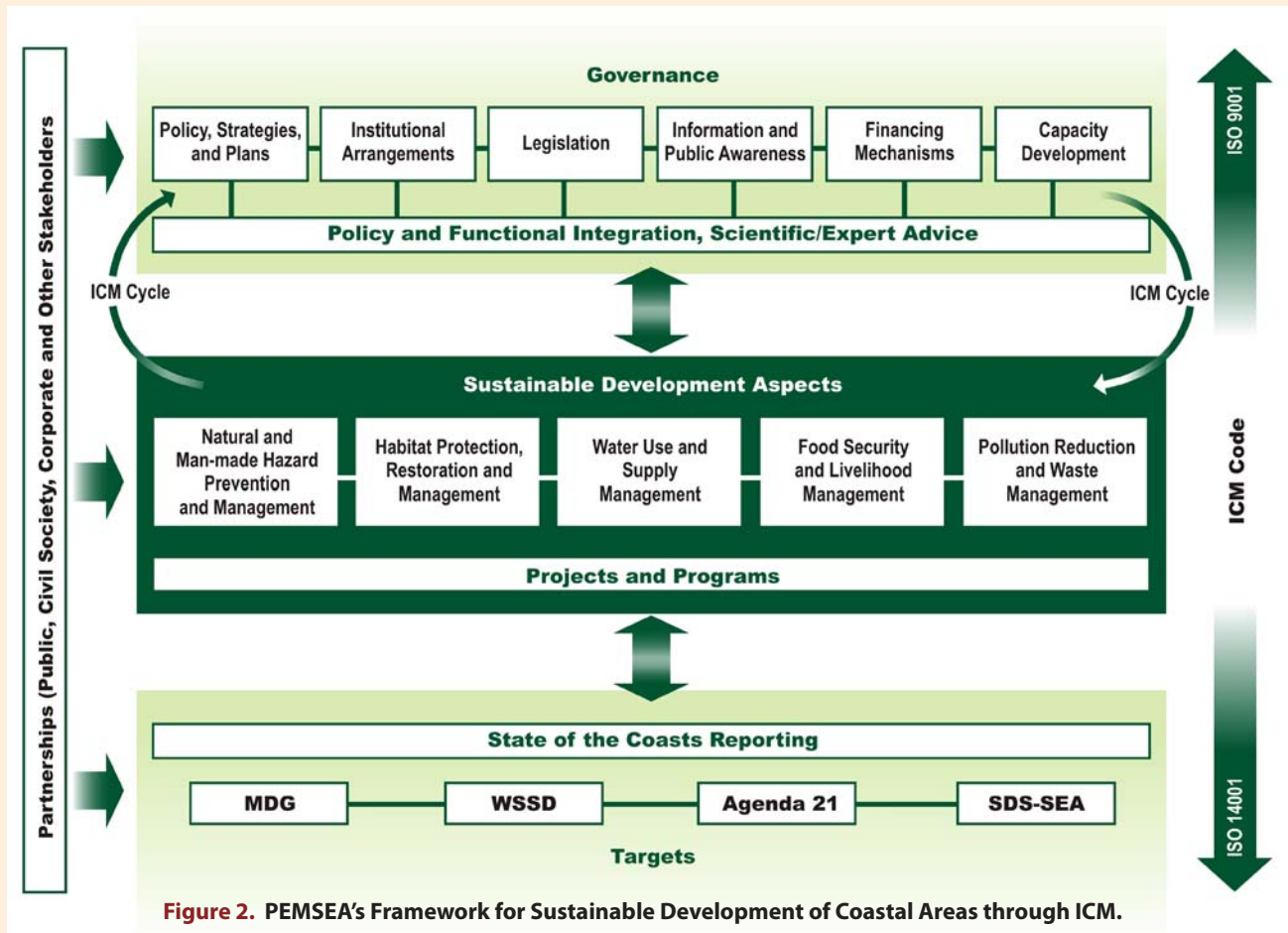
However, this changed after 1999. That year, Typhoon No. 9914, the strongest typhoon (in terms of rainfall and winds) to have struck Xiamen since 1959, caused direct economic losses of about 1.938 billion RMB (See Box 1). Electrical power, water supply, gas supply, some telecommunication networks were interrupted and many city roads were impassable. Most production enterprises closed for several days. Large tracts of farmland were flooded as well as tens of thousands of square meters of offshore farms were destroyed.

management and law enforcement (**Box 2**). Integral to the framework of sustainable development of coastal areas (**Figure 2**), natural and man-made hazard prevention and management was identified as a key area in coastal profiling and response actions were included in Xiamen Coastal Strategy.

## Improving Emergency Response Plans

In contrast to the plan specifically for typhoons and floods, the Xiamen Municipal Overall Public Emergencies Plan was

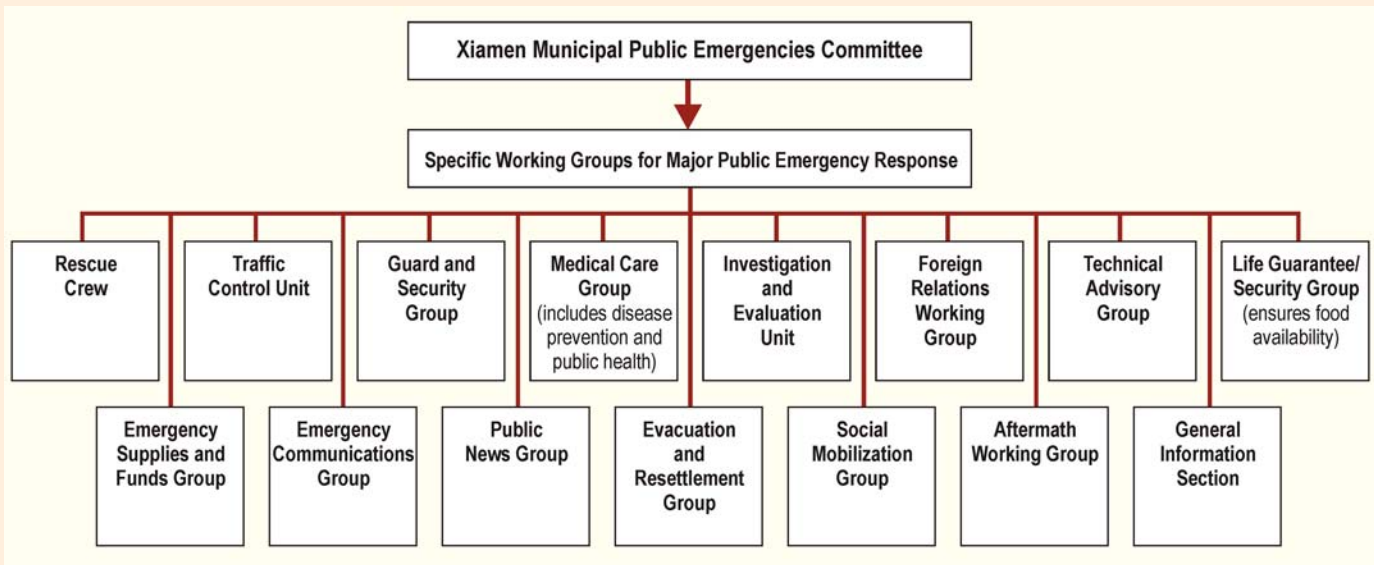
developed in 2004 to effectively manage various public emergencies. Under the framework of the plan, all relevant departments should formulate their special emergency response plans pertinent to their mandates. The plans relevant to marine disasters are listed in **Table 1**. These plans clarify the responsibilities of the leading departments and the supporting departments. Annual drills and exercises are carried out under the supervision of the government according to the plans. Many of the original plans have since been updated and improved, incorporating experiences and lessons from their implementation.



**Table 1. Plans related to marine disasters.**

| Year   | Program/Plan  | Main Responsible Agency         | Contents   |
|--|---|---------------------------------|--|
| First adopted in 1999<br>Revised in 2006, 2009 | Emergency Response Plan for Typhoons and Floodings                                    | Water Resource Bureau           | Implements emergency rescue actions according to the strength of the typhoon, and coordinates the activities of emergency rescue and disaster relief during severe weather events  |
| First adopted in 2002<br>Revised in 2008       | Xiamen Marine and Fishery Emergency Response Work Plan for Typhoons                   | Oceans and Fisheries Bureau     | Clarifies the actions and roles to be taken by relevant sectors in response to marine emergencies to effectively reduce the harm to fisheries, fishers and property  |
| First adopted in 2004<br>Revised in 2009       | Emergency Response Plan for Marine Pollution from Ships                               | Maritime Affairs Bureau         | Implements emergency rescue actions according to the degree of severity of shipping pollution, and clarifies the responsibilities of the relevant departments  |
| 2005   | Emergency Response Plan for Storm Surges and Tsunamis                                 | Oceans and Fisheries Bureau     | Establishes early warning and emergency response mechanism, improves forecasting of coming storms, and ensures that response measures can be done quickly and effectively to minimize the storm surge disaster loss                  |
| First adopted in 2005<br>Revised in 2009       | Xiamen Emergency Response Plan for Red Tides  | Oceans and Fisheries Bureau     | Sets up the early warning mechanism and conducts emergency rescue actions according to the degree of severity of red tides and coordinates the relevant emergency security support activities to reduce losses due to red tide       |
| 2006   | Xiamen Emergency Response Plan for Environmental Pollution and Ecological Destruction | Environmental Protection Bureau | Addresses prevention and rapid response to environmental pollution and ecological destruction emergencies  |
| 2008   | Emergency Response Guidelines for Precautions of Gaoqi Fishery Harbor against Floods  | Oceans and Fisheries Bureau     | Establishes a leadership team to coordinate the preparation for typhoons and storms in Gaoqi port, implements safety measures during typhoons, and conducts emergency rescue actions according to the degree of severity of typhoons |

**Figure 3. Specific Working Groups for Major Public Emergency Response in Xiamen.**



### Putting in Place an Organizational Arrangement

The Xiamen Municipal Government established a Public Emergencies Committee responsible for leading, organizing and directing responses to public emergencies, and supervising relevant departments to develop preventive measures,

emergency preparedness and response, rehabilitation and reconstruction in an effective and timely manner. At the same time, for major public emergencies, the committee has established several working groups for particular tasks during emergency responses, providing clarification on main tasks and supporting roles for various departments (Figure 3).



In order to prevent and reduce marine disasters, the Xiamen Oceans and Fisheries Bureau set up a corresponding lead group and office for disaster management. The members of the Emergency Management Office consist of the Department of Fisheries, the Department of Policies and Regulations, the Department of Resources and Environmental Protection, the Department of Sea Area Management, the Marine Comprehensive Law Enforcement Detachment, the Department of Fishing Vessel Management, the Safe Harbor Administration, the Xiamen Ocean and Fisheries Environment Monitoring Station, the Xiamen Fisheries Technical Extension Station, and other departments.

### Strengthening Marine Disaster Early Warning and Forecasting System

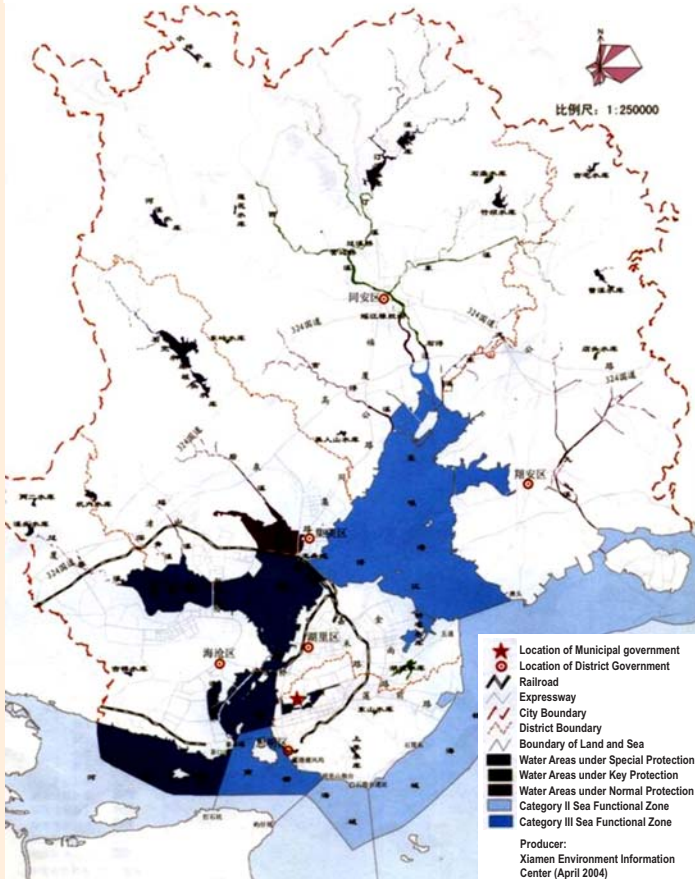
Xiamen has established a municipal flood control and command center that is equipped with state-of-the-art hardware and software for receiving and communicating flood information supported by a Flood Forecasting and Warning System, the Automatic Reception System of Wind Regime and Satellite Image, Typhoon Path Analysis System, Real-time Remote Video Flood Monitoring System, 3-Level (City, District, and Sub-district) Flood Defense Video Conference System, Flood Control Multi-Fax (facsimile) Communication System, and Flood Defense Mobile Phone Short Message Service (SMS) Communication System.



Figure 4. YSI automatic online monitoring.

The Xiamen marine environment forecast station has established the Numerical Prediction System of Ocean Dynamic Environment, Observational Data Communications and Management Systems, Real-time Marine Satellite Data Communications Network, Remote Video Conference System, and Urban Storm Surges Decision Support System to increase marine disaster warning and forecasting capability. Cooperation between the Xiamen Municipal Meteorological Observatory, Xiamen Hydrological Branch, and Xiamen Marine Environmental Forecasting Station has enabled forecasting and prediction of storm surges, typhoons and floods up to 48 hours.

### Xiamen Water Quality Targets (2004–2010).



### Xiamen Water Quality Targets Beyond 2010.

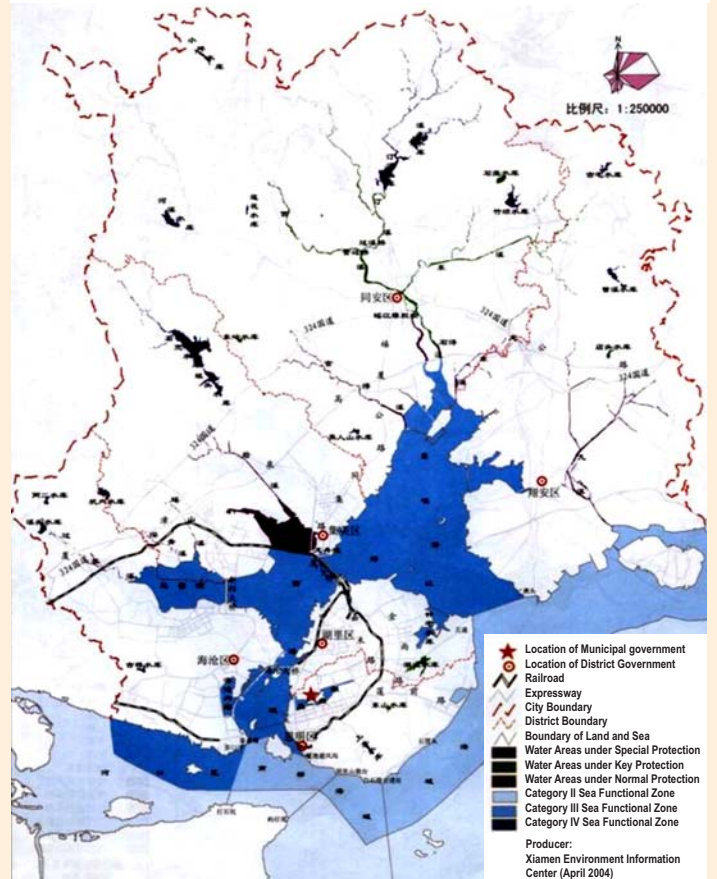
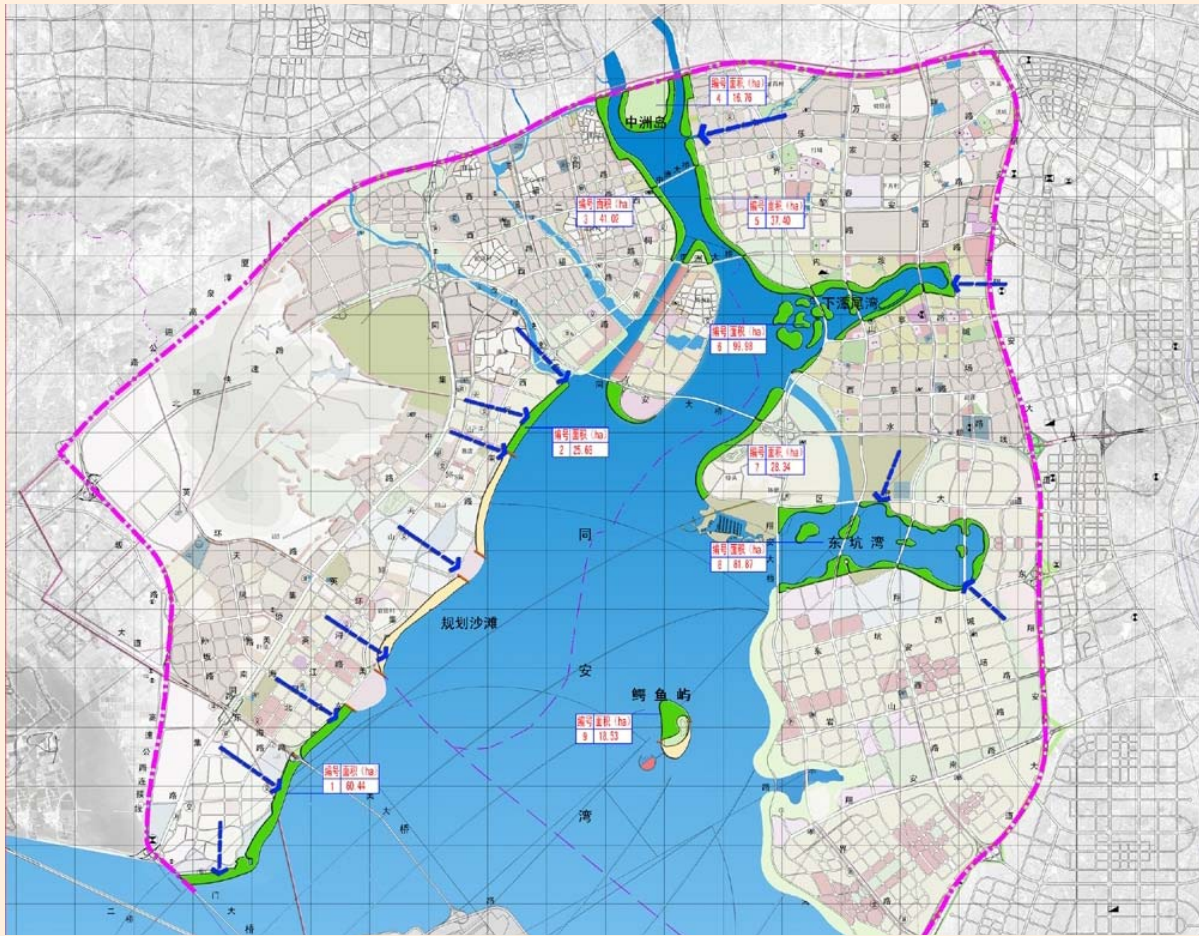


Figure 5. Water quality targets: (a) by 2010 and (b) beyond 2010 in Xiamen.



**Figure 6. Eastern Sea Mangrove Planting Plan.**

Since 2004, the Xiamen Oceans and Fisheries Bureau successively installed five Automatic Marine Water Quality Monitoring Buoys to be able to provide 24 hours of real-time online automatic monitoring and identification of significant factors associated with red tide (**Figure 4**). As a consequence, Xiamen has been releasing daily forecasting and early warning information about red tide events through newspapers and TV from May to October annually since 2005. This has resulted in 100 percent accuracy in forecasting red tides (China Ocean Yearbook, 2007).

### Enhancing Public Awareness

Radio, television, newspapers, internet, public service advertisements, contests and other means of communication tools are used to raise awareness and disseminate information on disaster prevention, mitigation and self-help. Copies of the education booklet entitled *Concise Guide to Flood Control and Drought* were distributed to all relevant districts. On-site awareness-raising activities are also organized and conducted, such as annual activities to improve awareness and knowledge among the public and school children regarding the prevention and reduction of marine disasters.

In the event of a disaster, all the city newspapers, television stations, radio stations, websites and other media are mobilized to broadcast the latest news. Messages are sent by mobile phones to release the pre-warning information to responsible persons/authorities and then to every household.

### Preventive Measures to Reduce Hazards from Land-based Pollutants

Prevention is always less expensive and more effective than post-disaster reduction of the damage from harmful algae blooms (HABs), including red tides. Xiamen legislated the use of sea areas in 1997 to harmonize coastal activities, including coastal development, and providing areas for environmental protection and rehabilitation. Seawater quality targets of different functional zones and specific actions to reduce land-based pollution are specified in the Water Environmental Functional Zoning (**Figure 5**) and the Marine Environmental Protection Plan. Planned actions include increasing the rate of domestic sewerage treatment, ecological restoration and rehabilitation, pollution reduction, etc. In 2008, 86.3 percent of domestic sewage was treated. To strive for zero emissions, the government is implementing a pilot project that delivers sewage up to the upland areas and reuses sewage to irrigate crops. Industrial enterprises are also encouraged to reuse water.

To address pollution loading to Xiamen Bay coming from upstream areas of the Jiulong River since 1999, Xiamen Municipal Government has invested 10 million RMB annually in the upstream cities of Longyan and Quanzhou for Jiulong River watershed environmental rehabilitation. Through concentrated treatment of pollutants from livestock and poultry farms, promotion of environment-friendly agriculture, installation of wastewater and garbage treatment facilities, and enhancing industrial pollution prevention, the water quality of Jiulong River has improved. In 2008, the river sections





**Figure 7. Gaoqi haven during typhoons.**

better than Class III or safe level have increased by 20.6 percent compared with 1999.

shoreline landscape, as well as provide protection against typhoons and storm surges in the East Sea area (Figure 6).

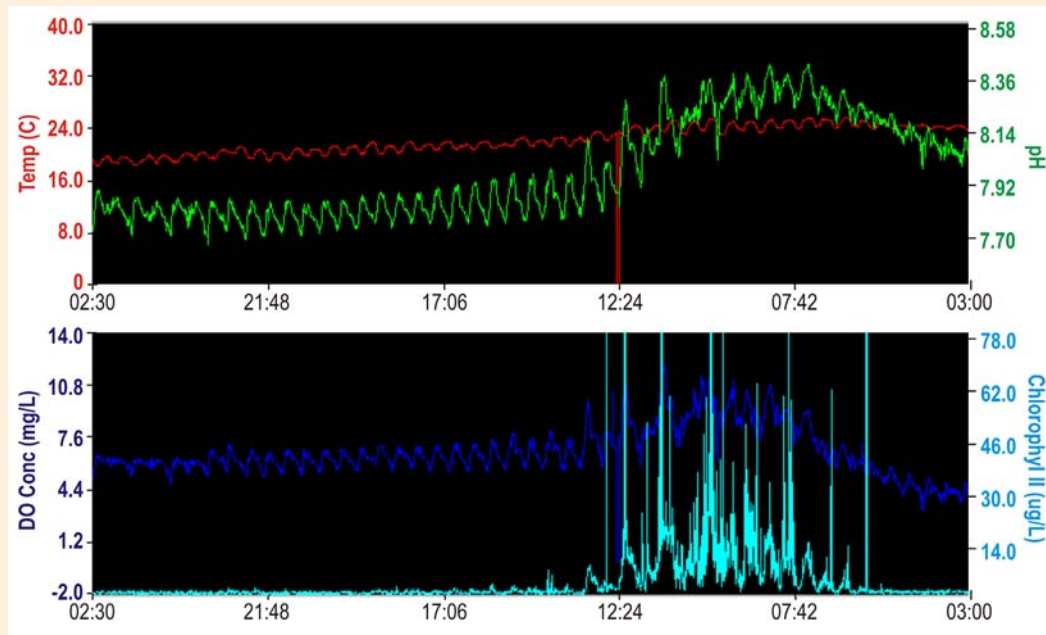
**Preparedness of Areas Vulnerable to Risk of Disasters**

In Xiamen, areas vulnerable to storm surges include the southeastern coast of Xiamen Island extending from Huli Ancient Fortress to Yefeng Village and the northeastern coast of Xiamen Island, or Wuyuan Bay (Sina Web, 2009). In the risk areas, Xiamen improved the design standard of flood defense projects and strengthened the sea wall and reservoirs. From 1997 to 2005, Xiamen constructed, renovated and strengthened a total of 316.61 km of dikes, including 124.45 km achieving a standard strength level, which can protect an estimated 372,000 people from storm surges. By 2008, Xiamen reinforced seven seawalls including those at Dongkeng, Xike and Haicang to resist one hundred-year high tide levels and 12th class typhoons. Xiamen has planted 3.3 hectares of mangroves and plans to plant another 53.3 ha to help improve water quality, beautify the

**Benefits of Disaster Risk Reduction Efforts**

In 2006, Xiamen was hit by five typhoons and a series of associated floods, among which No.1 typhoon “Pearl” was the strongest since 1949. Although this 2-million-people city suffered a loss of production from 10,000 ha of crops and collapse of 645 houses with an accumulated direct loss of 197 million RMB, this was far less than the direct loss of 1,938 million RMB from Typhoon No. 9914 in 1999 (Figure 7).

On March 15, 2008, a red tide (*Akashiwo sanguinea*) was signaled by the warning system. The Xiamen Ocean and Fisheries Bureau immediately implemented the Xiamen Emergency Response Plan against Red Tide. The Red Tide Technical Support Group was summoned to an emergency conference within two hours to



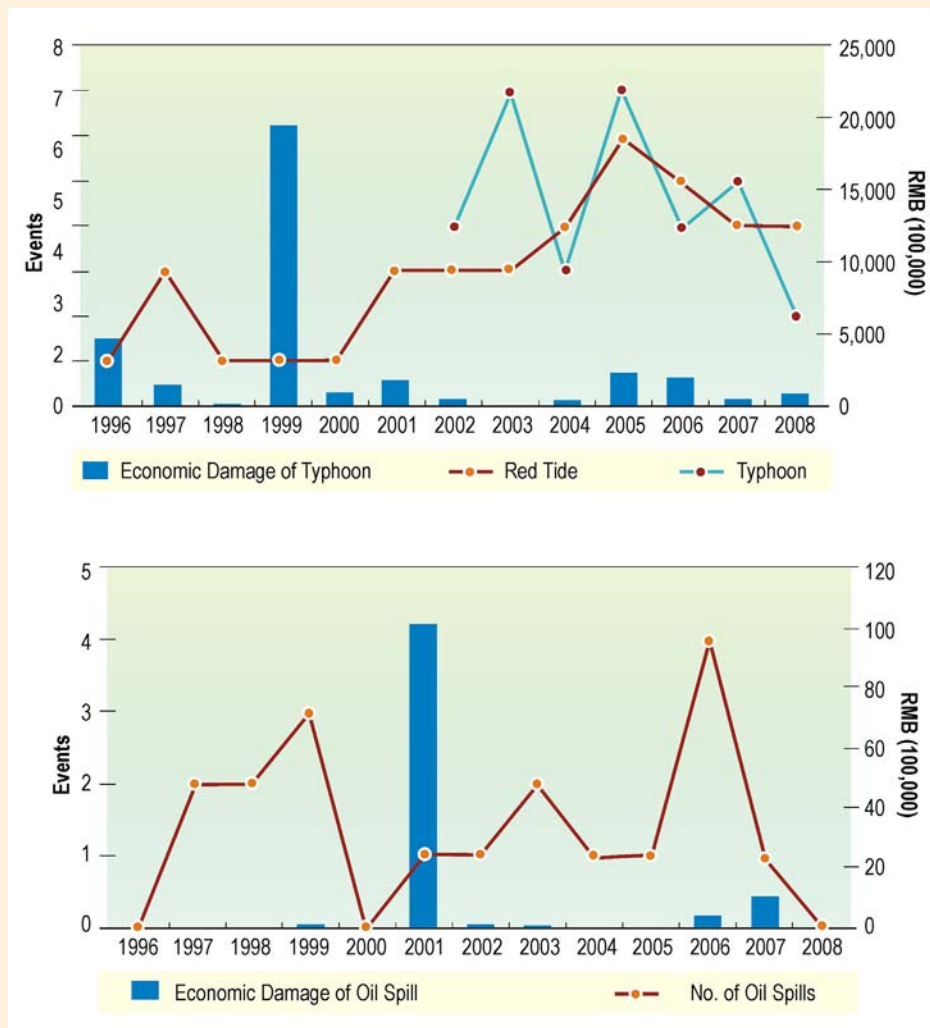
**Figure 8. The value of DO, pH, and chlorophyll before and after red tide.**



**Figure 9. Xiamen Shufa Guangchang before and after cleaning oil pollution in 2007.**

determine the type of red tide organisms and the causes of occurrence, and to predict their trend and potential impact. Following the quick response actions, the 20-day long red tide with a density up to  $5.26 \times 10^6/L$  and the largest occurring area to about  $60 \text{ km}^2$ , caused no direct economic loss or personal injury (Figure 8).

In 2007, an oil spill accident occurred in Shufa Guangchang in Xiamen. The Maritime Affairs Bureau, Ocean and Fishery Bureau and Environmental Protection Bureau in cooperation with other departments immediately implemented the planned response plan. The oil pollutants were subsequently removed within two days (Figure 9).



**Figure 10. Number of Disaster Incidents and Economic Losses due to Marine Disasters.**

## Experiences and Lessons Learned

There are indications that hazard-induced damage has decreased since Xiamen began strengthening its disaster prevention and management system (**Figure 10**), though it is still too early to statistically conclude a downward trend. Integrated disaster risk management is iterative process that requires continued improvement taking into account the experiences and lessons learnt on the ground. Xiamen Municipality has learned the following disaster prevention and mitigation lessons through its practice of recent years:

- Disaster risk management requires political will and a powerful integrated disaster mitigation lead organization, which can integrate information and resources quickly, and efficiently act within the window of opportunity of rescue. Coordination improves disaster mitigation;
- Capacity development is the key to success of emergency response efforts. This can be done through drills and exercises engaging all relevant government units and communities in disaster prone areas;

- To manage effectively, it is important to calibrate the response according to the severity of risks, and assign responsibilities appropriate to the capability of bureaus and districts;
- Improving the infrastructure of disaster-prone areas is a cost-effective investment to reduce marine disasters;
- Improving public awareness, education and community involvement in disaster mitigation is a basic and important way to reducing disaster risk; and
- Utilizing available technologies in forecasting and early warning provides timely, accurate and comprehensive management for disasters, and post-disaster rehabilitation work.

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