UNDP/GEF YSLME Phase II Project

Terms of Reference for the development of adaptive management strategy to enhance the resilience of YSLME and reduce vulnerability of coastal community to climate change impacts on ecosystem processes

(As of 22 June 2017)

Global and Regional Context

The oceans, covering more than 70% of the Earth's surface, include coastal, continental margin, open ocean, and sea-ice covered systems. The oceans play an important role in regulating climate by storing and redistributing materials, energy and heat. Since the beginning of the 19th century, the oceans are estimated to have taken up about 50% of fossil fuel emissions and about 30 % of anthropogenic emissions, thus significantly reducing the accumulation of atmospheric CO_2. Meanwhile, the oceans are experiencing significant variations on different space and time scales as a result of climate change, which in turn affect the human communities that rely on oceanic services and resources. It is known that Climate Change (CC) is having profound and long-term impacts on human welfare and adds another pressure on marine ecosystems that are already under threat from land-use change, pollution, over-harvesting, and the introduction of alien species. One estimate found that at least 40% of the global oceans are heavily affected by human activities (IOC/UNESCO et al. 2011). These changes are impairing the ocean's capacity to provide food, protect livelihoods, maintain clean water, and recover from environmental stresses like severe storms. The resilience of marine ecosystems to anthropogenic pressures is weaker than we thought and these trends are exacerbated by the growing human populations in coastal areas and increasing need for marine resources (Rombouts et al. 2013).

Impacts of global climate change on the YS

The Yellow Sea (YS) is a semi-enclosed marginal sea with depths ranging from 20 to 90 m in the West Pacific, bounded by China and Korea, and known for its high productivity and abundant fishery resources for last few decades. Interestingly, tidal ranges in the YS are among the highest in the world, and strong tidal fronts from parallel to the western coast of Korea. During the winter, warm, saline water originating from the Tsushima Warm Current (TWC) in the East China Sea, one of the branches of Kuroshio Warm Current, enters the YS episodically (Lin, et al., 2005) and cooler, fresher waters from rivers empty into the YS, flowing south along the coasts of eastern China and western Korea.

There are evidences that sea surface temperatures (SST) in the China seas increased in the last several decades. Since the 1980s, the Bohai Sea, Yellow Sea, and East China Sea have witnessed significant increase in SST (Cai et al. 2011 and Lin et al. 2005). The strongest warming was observed in the East China Sea in winter (1.96 °C) from 1955 to 2005 and in the Yellow Sea in summer (1.10 °C) from 1971 to 2006 (Cai et al. 2011).

Climate change may have important effects on the recruitment of pelagic species and shellfish in the Yellow Sea LME (Tang, 2009). Obvious changes in biological abundance and distributions in the YS marine ecosystems were observed. There has been an increasing proportion of warm water species relative to temperate species from plankton to fish in the past decades in the Yangtze estuary of the East China Sea and in the south Taiwan Strait (Li et al. 2009). Changes of dominant fishery species driven by multi-decadal climate variability have been reported (Gong et al. 2007). Warming-induced shift of the dominant fisheries occurred in the East China Sea from the 1960s to the 1980s (Chen and Shen 1999). The northward expansion of warm-water zooplankton species were observed in the Yangtze estuary (Kang et al. 2012; Tang 2009). The frequency of harmful algal blooms (HAB) in the East China Sea showed an inter-decadal trend showing increasing in the past decades (Tang 2009). As a result, larger, higher trophic level, and commercially important demersal species were replaced by smaller, lower trophic level, pelagic, less-valuable species (Tang 2009).

Significance of CWM in YS

In the YS, one of the most important physical features is the existence of the Yellow Sea Cold Water Mass (YSCWM) throughout the summer season. It is known that the YSWCM is the most particular phenomenon, and prevails from summer to fall with the boundary and temperature-salinity structure remaining almost unchanged each year (Choi, et al. 2011; Jang, et al. 2011; Liu et al., 2015A and B; Zhang, et al., 2008). The seasonal evolution of the YSCWM can be attributed to the unique basin topography and the impact of both the seasonal evolution of thermocline and the circulation system (Choi, et al. 2011; Zhang, et. al 2008). Also, the seasonal thermocline is an important physical barrier in the ocean, separating the well-lit, nutrient-poor and warm surface layer from the darker, nutrient -rich and cold deeper water (Zhang, et. al., 2008).

A previous study reported that the system in the central YS in summer was similar to the open ocean when the YSCWM prevailed (Zhang, et. al. 2008). All findings observed until now suggested that the ecosystem of the central area of the YS was different from the other regions in the southern YS. And it was identified that the southern YSCWM is a water mass that develops in summer and decays in fall (Choi, et al. 2011; Jang, et al. 2011; Yang, et al. 2014; Zhang, et. al. 2008). According to Zhang (2008), during summer season, the YSCWM has two cold cores. One is the northern YSCWM that lies at the bottom layer between Chengshanjiao and Dalian with temperature (< 8^{o}C) and the other is the southern YSCWM that has a tongue-like feature occupying the area approximately between 34^{o}N and 37^{o}N, 123^{o}E and 126^{o}E with temperature < 9^{o}C. It was suggested that the CWM in the northeast region has a displacement from the north to the central area of the YS.

The YSCWM has also been known to provide critical effect on the hydrographic features and the phytoplankton biomass and production in the YS. Recent studies observed a very strong spatial heterogeneity among the physical, chemical and biological parameters when the YSCWM occurred. In particular, in the central part, typically the abundance and/or community structure of organisms (phyto-/zoo-plankton) were derived from the supply of resources (e.g., nutrients) and/or by physical factors (e.g., temperature and/or salinity) during the YSCWM season, which are the fundamental characteristics of a bottom-up control system (Liu, et. al. 2015A and B; Xu, et. al. 2016; Xu, et al. 2017).

In brief, CC has resulted in increasing sea surface temperatures, changing the characteristics of the Yellow Sea Cold Water Mass (YSCWM) and the structure of plankton communities. It is worthwhile of carrying out further monitoring and studies which seem necessary for better understanding of these changes and identifying appropriate adaptive management.

YSLME approaches on the development of adaptive strategy

Impacts of CC in the YS ecosystem, in particular the impacts on the plankton community, had been studied in the demonstration sites of the YSLME Project Phase I with findings of changes of community structure. However, there is a need to add more efforts to assess the impacts of CC in the YS especially in line with effects of YSCWM. In this regard, an appropriate regional strategy was suggested by the UNDP/GEF YSLME Phase II Project to achieve adaptive management for tangible outcomes with new scientific information acquired from both countries.

The major efforts on adaptive management in response to CC will include preparation of regional strategies on adaptive management; site-based ICM plans, to enhance climate resilience for selected sites in YSLME; conservation areas and habitats for migratory species identified. The regional management strategy will be based on the scientific understanding of the impacts of CC on site-specific management.

During the period of the 1st Phase of YSLME Project, WWF, several conservation NGOs and research institutes in China, ROK and Japan carried out an "Assessment of YS Ecoregion Biodiversity" to prioritize conservation actions based on scientific data (Tobai, et al., 2008). Participants for this project agreed on the necessity to conduct assessments beyond political boundaries and also reached common understanding that CWM area is a unique and an important habitat because of its supporting capability for those isolated cold temperate species populations.

In this project, with understanding of significance of preparing countermeasures against impacts of CC, development of adaptive management strategy will contribute to the mutual benefits for both countries with target to conserve YS ecosystems. Detailed activities are encouraged to be implemented in line with goals of YSLME Phase II Project. One of the Outcomes of the Project is to strengthen MPA networks by conducting 1) analysis of country coastal management guidelines, identification of conservation areas and 2) survey to analyze gaps and conservation needs of critical species and habitats including CWM in the YS. It is expected that activities to be carried out here will support the other Outcome of the Project seeking developing regional strategies in Integrated Coastal management (ICM) and capacity building on YSCWM provided having linkage with CC. In order to achieve the latter Outcomes, understanding relationships between the changes in SST and characteristics of YSCWM and structure of plankton will be required and the information provided will enhance the development of regional strategy for adaptive management strategy to reduce vulnerability of coastal community and CC impacts on ecosystem process. Briefly, relevant Outputs and Activities proposed in the 3-year workplan for YSLME Phase II Project are described as follows:

- Output 4.2.1. MPA networks strengthened in the YSLME
    - ✓ Activity 2. Analysis of country coastal management guidelines, identification of conservation areas according to planning zones

- ✓ Activity 3. Survey and produce overlays to analyze gaps and conservation needs of critical species and habitats (i.e., seal, migratory birds, fish spawning and nursery, cold water mass, etc.) and make recommendations on new MPAs

- Output 4.3.1. Regional strategies adopted and goals agreed; site-based Integrated Coastal Management (ICM) plans enhancing climate resilience, in place for selected sites in YSLME; conservation areas and habitats for migratory species identified
  - ✓ Activity 1. Stock-taking of vulnerabilities of coastal communities and ecosystem services in YSLME to impact CC
  - ✓ Activity 2. Prepare communication package to raise awareness of vulnerabilities to impact of CC
  - ✓ Activity 3. Monitoring and studies of relationships between the changes in sea surface temperature and characteristics of YSCWM and structure of plankton communities and development of regional strategy for adaptive management
  - ✓ Activity 4. Workshops/training programs on CC and its impact on coastal and marine ecosystem services and adaptation
  - ✓ Activity 5. Develop CC adaptation ICM model framework plan or strategic framework plan for 2 coastal cities and provinces
  - ✓ Activity 6. Experience sharing and dissemination
- Output 4.4.2. Established monitoring network; regular basin-wide assessments; enhanced information exchange; periodic scenarios of ecosystem change; allocation of 1% of project budget for IWLEARN activities
  - ✓ Activity 4. Create regional jellyfish monitoring program: Create regional committee to coordinate monitoring, assessment and data sharing, and develop national and regional monitoring methodologies of jellyfish booms
  - ✓ Activity 5. Create regional HAB (including macro-algae) monitoring program: Create regional committee to coordinate monitoring, assessment and data sharing. Combine with jellyfish committee develop national and regional monitoring methodologies of HAB
  - ✓ Activity 6. Establish a comprehensive regional monitoring system: Develop regional monitoring strategies for N/P/Si changes, climate change, jellyfish blooms, and HAB

In order to be in line with the approach that YSLME Phase II set up, survey and monitoring are core activities to be implemented to understand effects of CC on physical, chemical and biological sectors by covering issues on fish/ plankton community and structure changes, trends of SST and forecast status of YS on the impacts of CC. With these overall categories in mind, several potential activities could be suggested as follows:

Deliverables and Tasks

Output 4.2.1. MPA networks strengthened in the YSLME

Deliverable 1. Rationalized network of MPA in YSLME that integrate the principle of connectivity

Description of tasks

- Conduct desk review of YSCWM in the perspective of ecological and biological significance in the YS.
- Identify potential anthropogenic pressure and threats (i.e. land-based as well as sea-based sources including marine litter) affecting ecosystem process in the YSCWM;
- Conduct survey and produce overlays to analyze gaps and conservation needs of critical species and habitats in the YSCWM and develop a technical report on biological and ecological significance and trends of CWM in providing the feeding grounds for various fish species.
- Assess the need and feasibility of including CWM in the YSLME MPA network by taking consideration of ecological connectivity – distribution of critical (major) species, their habitats, their population structure and trends of species diversity etc.

Duration: 10~12 months

Output 4.3.1. Regional strategies adopted and goals agreed; site-based Integrated Coastal Management (ICM) plans enhancing climate resilience, in place for selected sites in YSLME; conservation areas and habitats for migratory species identified

Deliverable 2. Technical report on climate-induced ecosystem changes in YS and adaptive management strategy

Description of tasks:

- Identify a coordinator for development of technical report on the climate-induced ecosystem in the YS and adaptive management strategy;

- Conduct reference review on physical, chemical and biological parameters when the YSCWM occurred. In particular, during the YSCWM season, find out relations of typical trends of the abundance and/or community structure of organisms (phyto-/zoo-plankton) with the supply of resources (e.g., nutrients), and/or by physical factors (e.g., temperature and/or salinity).
- Collate information indicating CC impacts on 1) effect of sea surface temperature (SST) on marine organisms (including starting from plankton to top predator levels like fish) and 2) trends of migratory fishes in last decades in the YS and distribution of critical fish species;
- Analyze 1) spatial and temporal patterns of biomass and community structure of marine organisms covering plankton to fish levels in the YSCWM; 2) roles of YSCWM on fish spawning and habitat conservation; 3) Extreme weather conditions affecting formation and expansion of CWM, 4) effect of CWM on the population of dominant fish species and their community structure and 5) forecast migration pattern of fish population (focused on critical species) in the region;
- Develop regional management strategy to enhance resilience and reduce vulnerabilities, together with site-specific management approach;
- Organize a Regional Workshop/training program focused on the CWM to share findings and ways to go forward
- Finalize the draft for review and recommendation for adoption by MSTP and Interim Commission Council.

Duration: 18~20 months

Output 4.4.2. Established monitoring network; regular basin-wide assessments; enhanced information exchange; periodic scenarios of ecosystem change; allocation of 1% of project budget for IWLEARN activities

Deliverables 3. Regional jellyfish and HAB monitoring programs established and implemented in collaboration with partners

Description of tasks:

- Identify a coordinator for collating relevant information and developing monitoring programs for Jellyfish and HAB in the NWP region;
- Conduct monitoring and assessment of Jellyfish species and species causing HAB in the YS;
- Analyze relationship of CWM with Jellyfish and species causing HAB in the YS.
- Develop jellyfish and HAB monitoring program and share outcomes and introduce developed monitoring programs (e.g. NOWPAP CEARAC, IOC-WESTPAC etc.);

- Improve the program by reflecting comments from partners and experts;
- Finalize the draft for review and recommendation for adoption by MSTP and Interim Commission Council.

Duration: 16~18 months

Timeframe of relevant activities and budget

Output 4.2.1.	**MPA Network strengthened in the Yellow Sea**	**Years**	**Remarks**
	Activity 2. Analysis of country coastal management guidelines, identification of conservation areas	’17 - ‘18	PCA with FIO
	Activity 3. Survey and analysis of gaps and conservation needs of critical species and habitats	’17 - ‘18	PCA with NMEMC, FIO and YSFRI
Output 4.3.1.	**Regional strategies adopted and goals agreed; site-based Integrated Coastal Management (ICM) plans enhancing climate resilience, in place for selected sites in YSLME; conservation areas and habitats for migratory species identified**		
	Activity 1. Stock-taking of vulnerabilities of coastal communities and ecosystem services in YSLME to impact CC	2017	PCA with FIO
	Activity 2. Prepare communication package to raise awareness of vulnerabilities to impact of CC	2017	
	Activity 3. Monitoring and studies of relationships between the changes in SST and characteristics of YSCWM, structure of plankton communities and development of regional strategy for adaptive management	’17 - ‘19	PCA with FIO
	Activity 4. Workshops/training programs on CC and its impact on coastal and marine ecosystem services and adaptation	’18 - ‘19	

	Activity 5. Develop CC adaptation ICM model framework plan or strategic framework plan for 2 coastal cities and provinces	’18 - ‘19	
	Activity 6. Experience sharing and dissemination	’18 - ‘19	
Output 4.4.2.	Established monitoring network; regular basin-wide assessments; enhanced information exchange; periodic scenarios of ecosystem change; allocation of 1% of project budget for IWLEARN activities		
	Activity 4. Create regional jellyfish monitoring program: Create regional committee to coordinate monitoring, assessment and data sharing, and develop national and regional monitoring methodologies of jellyfish booms	’17 - ‘19	PCA with NMEMC
	Activity 5. Create regional HAB (including macro-algae) monitoring program: Create regional committee to coordinate monitoring, assessment and data sharing. Combine with jellyfish committee develop national and regional monitoring methodologies of HAB	’17 - ‘19	PCA with NMEMC
	Activity 6. Establish a comprehensive regional monitoring system: Develop regional monitoring strategies for N/P/Si changes, climate change, jellyfish blooms, and HAB	’17 - ‘19	PCA with NMEMC

In conclusion, the complexity of the YS ecosystem, in terms of its physical, chemical and biological interactions with the land and ocean, requires systematic and integrated scientific research to understand its responses to climate change and anthropogenic activities, and its impacts on society. Although considerable progress has been made during the last few decades, the studies of this complicated ecosystem are facing many challenges. In particular, due to various internal reasons in both countries, there is an apparent lack of national strategy and long-term mission especially on the area of adaptive management in response to impacts of climate change in the YS.

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