MEMFiS Annual Report 2021

Marine Ecosystem Modeling and Forecasting System in the China Seas and Northwestern Pacific (MEMFiS)

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1. Selected highlights

1.a.i. Selected scientific highlights since last report

Last report was submitted to SSC meeting, May/June 2020. Each highlight needs to be VERY short, bullet points, with a link to publication if applicable.

- ✓ *The high-resolution marine ecosystem forecasting system of the China Seas and Northwestern Pacific has been built in the National Marine Environmental Forecast Center. The system is divided into four sub-systems, including the Bohai Sea and Yellow Sea, the Yellow Sea and East China Sea, the South China Sea and the Ningde demonstration area of Fujian Province. The marine ecosystem forecasting products can be applied to the assessment of coastal ecological environment and serve the public. The website is http://202.108.199.24:8080/BJ_SZYB_Web/default.htm*
- ✓ *Human activities have altered the state of the ocean, leading to warming, acidification and deoxygenation. These changes impact ocean biogeochemistry and influence ecosystem functions and ocean health. The long- term global effects of these changes are difficult to predict using current satellite sensing and traditional in situ observation techniques. Autonomous platforms equipped with biogeochemical sensors allow for the observation of marine biogeochemical processes and ecosystem dynamics, covering a wide range of spatial and temporal scales. The international Biogeochemical- Argo (BGC- Argo) project is currently building a global,*

multidisciplinary ocean- observing network of autonomous Argo floats equipped with an extensive range of biogeochemical sensors. Other autonomous platforms, such as gliders and surface vehicles, have also incorporated such sensors, mainly operating on regional scales and near the ocean surface. Autonomous mobile assets, along with remotely sensed data, will provide the 4D information required to improve model simulations and forecasts of ocean conditions and ecosystem health. The relevant results are published in "Chai F, Johnson K S, Claustre H, et al. Monitoring ocean biogeochemistry with autonomous platforms. Nature Reviews Earth & Environment, 2020, 1(1):315-326. DOI: 10.1038/s43017-020-0053-y".

- ✓ *The phytoplankton and zooplankton biomass as well as nutrients in the southern region of Kuroshio Extension (KE) presents obvious decadal variability. Both local and remote links between biomass and physical properties are investigated by comparing satellite observations and the outputs from a biological-physical coupled model. The Regional Ocean Model System (ROMS) and Carbon, Silicate, and Nitrogen Ecosystem (CoSiNE) cover the entire Pacific Ocean. The ROMS-CoSiNE model captures the spatial distribution and decadal variation of the key biological variables including phytoplankton and zooplankton biomass and nutrients in the upper ocean around the KE. The decadal variation in the region is mainly caused by the westward-propagating signals that originate from the central and eastern North Pacific. Specifically, these signals are induced by the decadal oscillation of vertical displacement related to large-scale decadal Pacific modes, such as the North Pacific Gyre Oscillation (NGPO). The evidence obtained here includes not only from surface variables (sea surface height and surface chlorophyll) but also from the variables in the deeper ocean (thermocline, subsurface nutrients, upper 100-m phytoplankton and zooplankton biomass) in the KE region. The signals of the variables in the southern KE region significantly lag that of the NPGO in the central and eastern North Pacific by about 2–4 years. The upper ocean nitrogen budget to conducted to evaluate the contribution of vertical and horizontal advection for the decadal variation of nutrients. The relevant results are published in "Lin P, Ma J, Xiu P, et al. Decadal variability of nutrients and biomass in the southern region of Kuroshio Extension. Progress In Oceanography, 2020, 188: 102441. DOI: 10.1016/j.pocean.2020.102441".*

- ✓ *Based on measurements from an observing mooring system, the observational evidence of parametric subharmonic instability (PSI) that transfers energy from semidiurnal internal tides (ITs) to the subharmonic waves at the East China Sea continental shelf slope is presented for the first time. Although the mooring station is quite close to the energetic semidiurnal IT generation site, about 76 % of the observed shear variance is contained in the near-inertial band which is found to have comparable upward and downward propagating energy components. Bispectra and bicoherence estimates further confirm the occurrence of PSI transferring energy from the low-mode M 2 ITs (vertical wavelength of ~1000 m) to high-mode subharmonic waves (vertical wavelength of ~200 m). The calculated energy transfer rate (ε) reveals an averaged net value of ~5×10^{-9} W kg $^{-1}$. Strong temporal variation of ε is found which is not exactly in phase with the semidiurnal energy flux. After looking into the local vorticity fields, it is strongly suggested that the varying background relative vorticity associated with the evolving Kuroshio current has modified the efficiency of PSI at the mooring location through changing the local effective inertial frequency. The relevant results are published in "Yang W, Wei H, Zhao L. Parametric Subharmonic Instability of the Semidiurnal Internal Tides at the East China Sea Shelf Slope. Journal of Physical Oceanography, 2020, 50(4):907-920. DOI: 10.1175/JPO-D-19-0163.1."*

- ✓ *A three-dimensional physical-biological model of the coastal and marginal seas of China was used to analyze interannual and intra-seasonal variations in hypoxic conditions and identify the*

main processes controlling their generation off the Changjiang (or Yangtze River) estuary. The model was compared against available observations and reproduces the observed temporal and spatial variability of physical and biological properties including bottom oxygen. Interannual variations of hypoxic extent in the simulation are partly explained by variations in river discharge but not nutrient load. As riverine inputs of freshwater and nutrients are consistently high, promoting large productivity and subsequent oxygen consumption in the region affected by the river plume, wind forcing is important in modulating interannual and short-term variability. Wind direction is relevant because it determines the spatial extent and distribution of the freshwater plume, which is strongly affected by either upwelling or downwelling conditions. High-wind events can lead to partial reoxygenation of bottom waters and, when occurring in succession throughout the hypoxic season, can effectively suppress the development of hypoxic conditions, thus influencing interannual variability. A model-derived oxygen budget is presented and suggests that sediment oxygen consumption is the important oxygen sink below the pycnocline and that advection of oxygen in the bottom waters acts as an oxygen sink in spring but becomes a source during hypoxic conditions in summer, especially in the southern part of the hypoxic region, which is influenced by open-ocean intrusions. The relevant results are published in "Zhang H, Fennel K, Laurent A, et al. A numerical model study of the main factors contributing to hypoxia and its interannual and short-term variability in the East China Sea. Biogeosciences, 2020, 17(22):5745-5761. DOI: 10.5194/bg-17-5745-2020."

- ✓ *The impact of submesoscale vertical advection (SVA) on the primary productivity in the southern East China Sea has been investigated. The analysis is based on a comparison between two numerical simulations by using a three-dimensional coupled physical-biogeochemical model. One simulation directly resolves SVA on a high-resolution mesh, and the other leaves SVA unresolved on a low-resolution mesh. The high-resolution simulation outperforms the low-resolution simulation in reproducing the observed chlorophyll distribution, particularly in summer. Resolving SVA results in an approximately 40% increase in primary productivity during the summer, though SVA activity is relatively weak in this season compared to other seasons. Among multi-scale physical processes, SVA rather than mixing is found to be the most important vertical nutrient supply pathway from the nutrient-rich bottom water to the nutrient-depleted surface water in summer, particularly on the middle and outer shelves. The impact of SVA on the shelf is unique compared to the open ocean in that it efficiently enhances vertical supply of nutrient-rich subsurface waters to the nutrient-depleted surface layer. This study highlights the importance of SVA in promoting primary productivity in stratified shelf seas. The relevant results are published in "Meng Q, Xuan J, Zhang W, et al. Impact of Submesoscale Vertical Advection on Primary Productivity in the Southern East China Sea. Journal of Geophysical Research: Biogeosciences, 2020, 125(8): e2019JG005540. DOI: 10.1029/2019JG005540."*

- ✓ *The North Pacific Subtropical Gyre (NPSG) is an oligotrophic environment where a number of mesoscale eddies occur. With continuous measurements from Biogeochemical‐Argo (BGC‐Argo) floats, we showed that mesoscale eddies can significantly affect the subsurface chlorophyll maximum (SCM) and subsurface biogenic particles. Different responses of the SCM to the cyclonic and anticyclonic eddies and those between the eddy core and edge region were revealed by combining the results from tracked eddies. The variations in the SCM and subsurface particles were further shown to be statistically linked with changes in the dissolved oxygen in the upper oxygen minimum layer. Such an eddy‐induced oxygen change in the central gyre is unresolved in global‐scale coupled models but can contribute to the oxygen variability in oligotrophic environments. The relevant results are published in "Xiu P, Chai F. Eddies affect*

subsurface phytoplankton and oxygen distributions in the North Pacific Subtropical Gyre. Geophysical Research Letters, 2020, 47: e2020GL087037. DOI: 10.1029/2020GL087037."

1.a.ii. Selected scientific highlights over last 5 years *(2016-2021)*

- ✓ *The high-resolution marine ecosystem forecasting system of the China Seas and Northwestern Pacific has been built in the National Marine Environmental Forecast Center. The system is divided into four sub-systems, including the Bohai Sea and Yellow Sea, the Yellow Sea and East China Sea, the South China Sea and the Ningde demonstration area of Fujian Province. The marine ecosystem forecasting products can be applied to the assessment of coastal ecological environment and serve the public. The website is* *http://202.108.199.24:8080/BJ_SZYB_Web/default.htm*

- ✓ *Using multipal observational techniques, the dynamical processes, e.g., frontal activities, and their impacts on regional circulation and chlorophyll distribution in the South China Sea are comprehensively investigated. Series of results were published, such as "Wang Y, Yu Y, Zhang H, et al. Distribution and variability of sea surface temperature fronts in the South China Sea. Estuarine, Coastal and Shelf Science, 2020", "Yu Y, Wang Y, Cao L, et al. The ocean-atmosphere interaction over a summer upwelling system in the South China Sea, Journal of Marine Systems, 2020", "Chen H, Tang R, Zhang H, et al. Investigating the Relationship between Sea Surface Chlorophyll and Major Features of the South China Sea with Satellite Information. Journal of Visual Experiment, 2020, e61172", "Yu Y, Xing X, Liu H, et al. The variability of chlorophyll-a and its relationship with dynamic factors in the basin of the South China Sea, Journal of Marine Systems, 2019, 200: 103230", "Yu Y, Zhang H, Jin J, et al. Trends of sea surface temperature and sea surface temperature fronts in the South China Sea during 2003–2017. Acta Oceanologica Sinica, 2019, 38(4): 106–115".*

- ✓ The high-resolution coupled physical-biological model, namely ROMS-CoSiNE, successfully simulated the hypoxia off the Changjiang Estuary in 2006. The nutrients during hypoxia was transported via the discharge of Changjiang River and Kuroshio Current. The usage of dissolved oxygen in the sediment largely determined the scale of hypoxia. The relevant results are published in "Zhou F, Chai F, Huang D, et al. Investigation of hypoxia off the Changjiang Estuary using a coupled model of ROMS-CoSiNE. Progress in Oceanography, 2017, 159:237-254. *DOI: 10.1016/j.pocean.2017.10.008*".

- ✓ *The project investigated the cross-shelf water exchange near surface in the East China Sea, and the variability of seasonal intrusion of Kuroshio to the East China Sea. The relative position between Kuroshio Current and shelfbreak can impact the location of Kuroshio intrusion in winter, spring and summer via beta effect. The relevant results are published in "Yang D, Yin B, Chai F, et al. The onshore intrusion of Kuroshio subsurface water from February to July and a mechanism for the intrusion variation. Progress in Oceanography, 2018, 167:97-115. DOI: 10.1016/j.pocean.2018.08.004"*

- ✓ Based on the survey data, the seasonal and spatial characteristics of Trichodesmium in East China Sea and southern Yellow Sea have been analyzed. The N_2 fixation rates of Trichodesmium and its relationship with physicochemical properties were studied, which provided a nice case for Marine Environmental Forecast. The relevant results are published in "Jiang Z, Li H, Zhai H, et al. Seasonal and Spatial Changes in Trichodesmium Associated With Physicochemical Properties in East China Sea and Southern Yellow Sea. Journal of Geophysical Research Biogeosciences, 2018, 123(2), 509-530. *DOI: 10.1002/2017JG004275*".

- ✓ *Using a three-dimensional Pacific physical-biological model, namely ROMS-CoSiNE, the interannual variation of phosphate transport via Kuroshio intrusion (KIPT) in the eastern boundary of the East China Sea (ECS) was investigated, and its influence on the ECS biological process was also explored. The relevant results are published in "Lin Z, Wang X, Xiu P, et al. Boundary Phosphate Transport of the East China Sea and Its Influence on Biological Process. Journal of Geoscience and Environment Protection, 2019, 7(9): 79-104. DOI: 10.4236/gep.2019.79007".*

- ✓ *The parametric method of the sub-mesoscale temperature vertical convection term is used to improve the low-resolution model. Taking the East China Sea as a case study, a high-resolution hydrodynamic model of the East China Sea was established, and the role of sub- mesoscale processes in heat transfer across the transcline layer was studied in depth. The relevant results are published in "Xuan J, Su J, Wang H, et al. Improving low-resolution models via parameterisation of the effect of submesoscale vertical advection on temperature: A case study in the East China Sea. Ocean Modelling, 2019: 51-65. DOI: 10.1016/j.ocemod.2019.03.002".*

- ✓ *Using observational data and modeling results, the driving mechanisms for the strong interannual variability of chlorophyll in the northern South China Sea between different phases of ENSO was examined. Both cyclonic eddies and wind-induced mixing affect phytoplankton variability, but the former is the dominant factor regulating the interannual variability of chlorophyll during La Niña years, while the latter becomes the dominant one during El Niño years. The relevant results are published in "Xiu P, Dai M, Chai F, et al. On contributions by wind‐induced mixing and eddy pumping to interannual chlorophyll variability during different ENSO phases in the northern South China Sea. Limnology and Oceanography, 2019, 64(2): 503-514. DOI: 10.1002/lno.11055".*

- ✓ *Observations from two Bio-Argo floats deployed in the northern and central South China Sea show distinct seasonal patterns of vertical chlorophyll distribution. Using the coupled physical-biological model, the roles of wind-and buoyancy flux-induced mixing on phytoplankton dynamics in the northern and central South China Sea was evaluate. The relevant results are published in "Geng B, Xiu P, Shu C, et al. Evaluating the Roles of Wind-and Buoyancy Flux-Induced Mixing on Phytoplankton Dynamics in the Northern and Central South China Sea. Journal of Geophysical Research, 2019, 124(1): 680-702. DOI: 10.1029/2018JC014170".*

- ✓ *By combining multiple satellite products to resolve both mesoscale and submesoscale dynamic regimes, the contributions of submesoscale processes associated with mesoscale eddies were evaluated. In worldwide subtropical gyres, the contribution of submesoscale structures around mesoscale eddies to high chlorophyll is comparable to that of mesoscale eddies (34.1% versus 30.8%). The relevant results are published in "Guo M, Xiu P, Chai F, et al. Mesoscale and submesoscale contributions to high sea surface chlorophyll in subtropical gyres. Geophysical Research Letters, 2019, 46(22): 13217-13226. DOI: 10.1029/2019GL085278".*

- ✓ *Based on long-term observation data, the summertime oxygen depletion and acidification in the bottom water of Bohai Sea was explored, and how the changes of phytoplankton community structure effect on dissolved oxygen were also analysed. The relevant results are mainly published in "Song G, Zhao L, Chai F, et al. Summertime Oxygen Depletion and Acidification in Bohai Sea, China. Front. Mar. Sci.,2020, 7:252. DOI: 10.3389/fmars.2020.00252".*

- ✓ *Linking extensive in-situ datasets with a coupled physical-biological model, namely ROMS-CoSiNE, the physical and biogeochemical processes that create high-biomass phytoplankton*

production and hypoxia off the Changjiang (Yangtze River) Estuary in the East China Sea was investigated. The relevant results are published in "Zhou F, Chai F, Huang D, et al. Coupling and Decoupling of High Biomass Phytoplankton Production and Hypoxia in a Highly Dynamic Coastal System: The Changjiang (Yangtze River) Estuary. Frontiers in Marine Science, 2020. DOI:10.3389/fmars.2020.00259".

- ✓ *The 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop took place in Hangzhou, China on 14-17 April 2019. The workshop was attended by 270 participants from 108 institutions of 62 countries to a) discuss emerging aspects from the coupled effects of ocean acidification with multi-stressors, b) review global ocean acidification status and forecast capabilities, and c) explore opportunities for capacity development. It was the fourth in a series, but the first time in China (even Asia), that aimed to build a sustained observing system for ocean acidification and the related biological responses that extends from local to global scales. This workshop has effectively promoted China's participation in this global network. It also helped boost up the construction and development of ocean acidification observing systems in China. Through mini-training-workshop and sharing of data, this workshop contributed to promote and enhance these countries' capacities in addressing global climate change impacts. It provided an arena for China to share her vision and solutions to global marine environmental governance and climate change. See http://www.goa-on.org/workshops/hangzhou2019/workshop.php for further information.*

1.b. Publications since last report

Please add all publications since last report to the table below (see notes for details on "Class" and "Activity" fields).

***Publication** with DOI*	***Class 1, 2, 3***	***Activity****
Chai F, Johnson K S, Claustre H, et al. Monitoring ocean biogeochemistry with autonomous platforms. Nature Reviews Earth & Environment, 2020, 1(1):315-326. DOI: 10.1038/s43017-020-0053-y	*3*	
Lin P, Ma J, Xiu P, et al. Decadal variability of nutrients and biomass in the southern region of Kuroshio Extension. Progress In Oceanography, 2020, 188: 102441. DOI: 10.1016/j.pocean.2020.102441	*3*	
Yang W, Wei H, Zhao L. Parametric Subharmonic Instability of the Semidiurnal Internal Tides at the East China Sea Shelf Slope. Journal of Physical Oceanography, 2020, 50(4):907-920. DOI: 10.1175/JPO-D-19-0163.1.	*3*	
Zhang H, Fennel K, Laurent A, et al. A numerical model study of the main factors contributing to hypoxia and its interannual and short-term variability in the East China Sea. Biogeosciences, 2020, 17(22):5745-5761. DOI: 10.5194/bg-17-5745-2020.	*3*	
Meng Q, Xuan J, Zhang W, et al. Impact of Submesoscale Vertical Advection on Primary Productivity in the Southern East China Sea. Journal of Geophysical Research:	*3*	

Biogeosciences, 2020, 125(8): e2019JG005540. DOI: 10.1029/2019JG005540.		
Xiu P, Chai F. Eddies affect subsurface phytoplankton and oxygen distributions in the North Pacific Subtropical Gyre. Geophysical Research Letters, 2020, 47: e2020GL087037. DOI: 10.1029/2020GL087037.	*3*	
Wu Q, Wang X, Liang W, et al. Validation and application of soil moisture active passive sea surface salinity observation over the Changjiang River Estuary. Acta Oceanologica Sinica, 2020, v.39(04):5-12. DOI: CNKI:SUN:SEAE.0.2020-04-001.	*3*	
Xu L, Yang D, Greenwood J, et al. Riverine and Oceanic Nutrients Govern Different Algal Bloom Domain Near the Changjiang Estuary in Summer. Journal of Geophysical Research: Biogeosciences, 2020, 125(10): e2020JG005727. DOI: 10.1029/2020JG005727.	*3*	
Tian D, Zhang H, Zhang W, et al. Wave Glider Observations of Surface Waves During Three Tropical Cyclones in the South China Sea. Water, 2020, 12(5):1331. DOI: 10.3390/w12051331.	*3*	
Xing C, Zhao Q, Cao X, et al. Summertime Bottom Water Transport in the Bohai Strait, China. Regional Studies in Marine Science, 2020, 35: 101210. DOI: 10.1016/j.rsma.2020.101210.	*3*	
Shi Y, Yang D, He Y. Numerical study on interaction between eddies and the Kuroshio Current east of Taiwan, China. Journal of Oceanology and Limnology, 2020:1-15. DOI: 10.1007/s00343-020-0010-0.	*3*	
Yang Q, Liu H, Lin P. The effect of oceanic mesoscale eddies on the looping path of the Kuroshio intrusion in the Luzon Strait. Scientific Reports, 2020, 10(1):636. DOI: 10.1038/s41598-020-57487-9.	*3*	

**If appropriate, please list the IMBeR activity through / by / from / during which the publication arose*

*******Notes on publications*******

Publications are logged in the IMBeR Zotero library which is publicly accessible online - https://www.zotero.org/groups/2448334/imber_library_2/library

[Due to space limitations, publications from 1999-2017 are in a separate Zotero library - https://www.zotero.org/groups/38770/imber_library_1/library]

Publications are categorised by "Class" and linked to "Activities":

Class 1 publications are specifically generated through/by/from/during ***IMBeR activities*** - for example, arising from IMBIZOs and IMBeR conferences such as the IMBeR open science meeting and the IMBeR

CJK symposia and from the activities of the working groups, regional programmes and the SPIS scoping teams.

Class 2 publications are on topics relevant to the IMBeR Science Plan that benefitted from some interaction with IMBeR or ***IMBeR activities***, for example by IMBeR symposium attendees, past and present SSC members, working group, regional programme and endorsed project members, or national contacts.

Class 3 publications are on topics relevant to the IMBeR Science Plan but for which there is no direct link to or benefit from an IMBeR activity. These might include publications by SSC members, working group, regional programme or endorsed project members or members of the IMBeR international community that were written as part of the normal scientific activity of the authors and would have occurred irrespective of IMBeR's existence. You can report Class 3 publications, but they will no longer be logged in the IMBeR database.

[See https://drive.google.com/open?id=1OQWn41KJvQ-LyWJlkiYnc5qZ2IuNQOrg or https://pan.ecnu.edu.cn/p/DTrpUb4QiFAYoQ4 for further information on "What is an IMBeR publication?".]

Why list 'Class' and 'Activity'? This helps us to declare authentically which publications IMBeR has helped to generate, and it makes it easier for us to demonstrate the value of the Regional Programmes, the Working Groups, the Endorsed Projects, and IMBeR in general, and it helps us to justify support for IMBeR activities when we can list tangible outputs.

1.c. Events, Meetings, and Workshops

List all international and national events, meetings and workshops. Describe the level of participation: e.g. chairing session/workshop, organising meeting. Include Endorsed Project meetings and workshops.

Format: Title of event. Date. Location. Description of participation. Any other pertinent details.

- ✓ *Project Workshop on the Application of Marine Ecosystem Forecasting System. 28 April, 2020. Zoom Cloud Meetings. 28 members of our project attended this meeting. This workshop mainly focused on discussing the problems related to the operational running and application of the high-resolution marine ecosystem forecasting system of the China Seas and Northwestern Pacific.*
- ✓ *Project Progress Meeting. 9 June, 2020. Zoom Cloud Meetings. 32 members of our project attended this meeting. We held this meeting aim to a) summarize the project work in the past half year, b) discuss and solve the problems of project, c) arrange work tasks for the next half year.*
- ✓ *Invited Keynote Speaking. 16 January, 2020. Dr. Yuntao Wang was invited to present the Marine Ecosystem Modeling and Forecasting System in China Seas and Northwestern Pacific (MEMFiS) as a Keynote Speaking in the MoU Signing Ceremony between the East China Normal University (ECNU) and the Integrated Marine Biosphere Research (IMBeR) project.*

2. International collaboration and links

- ✓ *The Symposium on Harmful Algal Blooms and Hypoxia in a Changing Ocean held in Hangzhou China on 25-26 May, 2018. More than 150 experts and scholars from 10 countries and regions attended the Symposium. This Symposium aims to promote the integration and joint research of harmful algal blooms and marine hypoxia, share data and technical achievements of marine observation and numerical prediction, and have a deeper and comprehensive understanding of the threat of eutrophication to the coastal ecosystem. See https://www.163.com/dy/article/DJ74KESM0511KMS0.html for further information.*

- ✓ *The 20th International Argo Steering Team Meeting (AST-20) and First International BGC-Argo Science Team meeting hosted by the State Key Laboratory of Satellite Ocean Environment Dynamics (SOED) was successfully held in Hangzhou on 11-15 March, 2019. About 55 AST members and national representatives from 15 countries were invited to attend the meeting. The theme of this meeting was focused on the "Argo2020 vision", and the projection for the international Argo program in the next 10-20 years.* See *http://www.argo.org.cn/index.php?m=content&c=index&a=show&catid=58&id=241 and http://www.argo.org.cn/index.php?m=content&c=index&a=show&catid=58&id=118 for further information.*

- ✓ *The 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop took place in Hangzhou, China on 14-17 April, 2019. The workshop was attended by 270 participants from 108 institutions of 62 countries to a) discuss emerging aspects from the coupled effects of ocean acidification with multi-stressors, b) review global ocean acidification status and forecast capabilities, and c) explore opportunities for capacity development. It was the fourth in a series, but the first time in China (even Asia), that aimed to build a sustained observing system for ocean acidification and the related biological responses that extends from local to global scales. See http://www.goa-on.org/workshops/hangzhou2019/workshop.php for further information.*

- ✓ *Prof. Mark Wells was invited as a visiting scientist for our project and co-authored the paper that investigate the coupling and de-coupling between high-biomass phytoplankton production and hypoxia off the Changjiang (Yangtze River) Estuary in the East China Sea due to sinking-caused time lag and vertical current shear. The relevant results are published in "Zhou F, Chai F, Huang D, Wells M, et al. Coupling and Decoupling of High Biomass Phytoplankton Production and Hypoxia in a Highly Dynamic Coastal System: The Changjiang (Yangtze River) Estuary. Frontiers in Marine Science, 2020. DOI:10.3389/fmars.2020.00259". https://www.researchgate.net/publication/340582610_Coupling_and_Decoupling_of_High_Biomass_Phytoplankton_Production_and_Hypoxia_in_a_Highly_Dynamic_Coastal_System_The_Changjiang_Yangtze_River_Estuary*

3. Input to management, policy and governance

Add anything that in line with the IMBeR Grand Challenge III: Improving and achieving sustainable ocean governance

3.a. Input to management and policy over the last year

Add anything that in line with the IMBeR Grand Challenge III: Improving and achieving sustainable ocean governance

The MEMFiS project, as one of the serial efforts from marine scientists to understand the changing Chinese coast and shelf under multi-pressure, has obtained more attraction from the policy-makers. An experimental mission to monitoring and early-warning of hypoxia and coastal acidification has been launched and supported by the government as a part of the long-term strategies trying to recovery the health of the Yangtze River Estuary.

3.b. Input to management and policy – Highlights from past 5 years

A marine field station aiming at the Yangtze River Estuary (http://yangtzeriverestuary.soed.org.cn/) has been approved by the Ministry of Natural Resources, China, in 2019, leading by the Second Institute of Oceanography, to extend the long-term monitoring activities from the irregular research purpose to regular operational mission, in a hope to collect sufficiently long time series of interdisciplinary data.

4. Education and outreach

- ✓ *With the support of our project, 5 Master students were successfully graduated in 2020. The training of graduate students can export more high-quality talents for the marine study team.*

5. Planned activities for next year

Our project will be completed on June, 2021. An online meeting is planned in May 2021 for presenting the outcomes during the execution of the project.

Activities and Outreach (Convening sessions, meetings, etc)

The project Assessment Acceptance will be carried out from July to December, 2021.