【Grant-in-Aid for Scientific Research (S)】

Comprehensive assessment of offshore ecosystem vulnerability to marine heat waves

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Project Information	Project Number : 24H00075　Project Period (FY) : 2024-2028 Keywords : Global warming, Marine Ecosystems, Foodweb, Material cycle, Biodiversity concervation

Purpose and Background of the Research

●Outline of the Research

Marine heatwaves, where seawater temperatures become extremely high for five or more consecutive days, have been increasingly common in many parts of the world. They are thought to be the result of natural cycles of rising ocean temperatures, which manifest themselves in extreme forms due to ocean warming. As the effects of climate change spread across the globe, these heat waves are increasing in frequency and intensity. Marine heatwaves are serious because, unlike long-term, gradual environmental stresses such as rising water temperatures and acidification, they cause drastic changes in community structure in a very short time, and their effects can last for many years. Ecosystems, where dominant species are replaced by intense environmental stress caused by marine heatwaves, do not return to their original state after the heatwave subsides. This means that the ecosystem transitions beyond a tipping point, resulting in a permanent shift to a new phase. Frequent marine heatwaves are likely causing rapid and unknown changes to the current marine ecosystem. To ensure sustainable ocean ecosystem services, it is crucial to quantify ecosystem responses to ocean heat waves, accurately predict their impacts, and implement appropriate mitigation and adaptation measures.

Currently, studies on the impact of marine heat waves on ecosystems have mainly been conducted in coastal areas. Conversely, the impact of marine heatwaves on offshore ecosystems, which account for 90% of the ocean area, remains poorly understood. This is because research opportunities are limited, and the ecosystem components range from phytoplankton, which are only a few μm in size, to cetaceans, which are over 10 m long. Additionally, these components vary over a variety of spatiotemporal scales, making it difficult to gain an overall picture of community change. To comprehend the impact of marine heat waves on offshore ecosystems, it is crucial to establish a new wide-area observation system and comprehensively evaluate the community response based on this system. This will help us understand the effects of marine heat waves on offshore ecosystems.

To address this issue, we will establish a new observation system（Fig.1）.

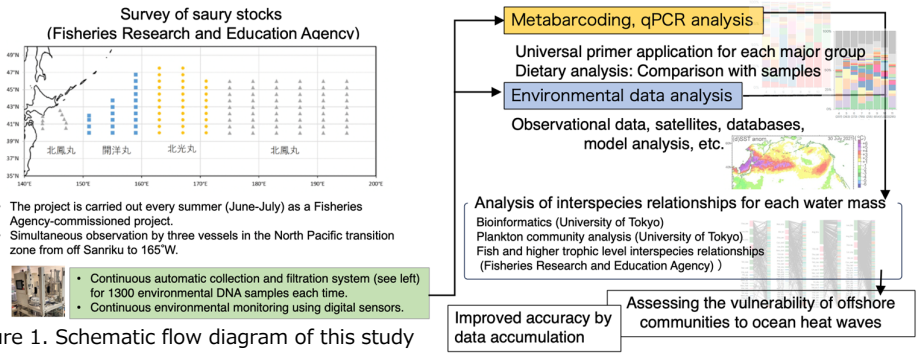

Figure 1. Schematic flow diagram of this study

Three research vessels equipped with automated water sampling and filtration equipment will simultaneously observe the North Pacific transition zone. This zone extends 4,500 km offshore from Sanriku in the summer every year. The vessels will collect wide-area high-resolution environmental DNA samples in just one month. In addition, we will analyze the ecosystem network that covers all levels of organisms in this system, along with the physical and chemical oceanographic data obtained simultaneously. This will allow us to comprehensively assess the vulnerability of the offshore ecosystem to marine heat waves.

●Importance of Research area

Transition zone of North Pacific is a crucial area for global ecosystem services, including fisheries resource production, greenhouse gas absorption, and marine biodiversity conservation. This area has been designated as a primary target by the North Pacific Marine Science Organisation (PICES). In recent years, we have observed frequent marine heat waves in this area (Fig. 2). We believe that this is likely to impact the diverse ecosystem services provided by this area. This research will provide quantitative data on ecosystem vulnerability, which will contribute directly to the development of fisheries resource management methods. The data will also aid in the identification of important marine areas and priority protected species to maintain species diversity. Additionally, it will inform policies and social advocacy aimed at reducing CO_2 emissions.

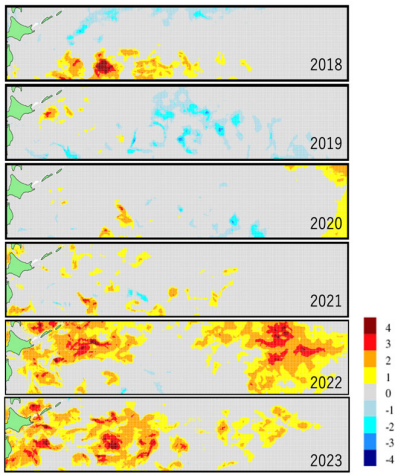

Figure 2. Marine heat wave occurrence in the research area in June 2018–2023

Expected Research Achievements

●Comprehensive assessment of the vulnerability of the North Pacific transition zone ecosystem to marine heat waves (Figure 3)

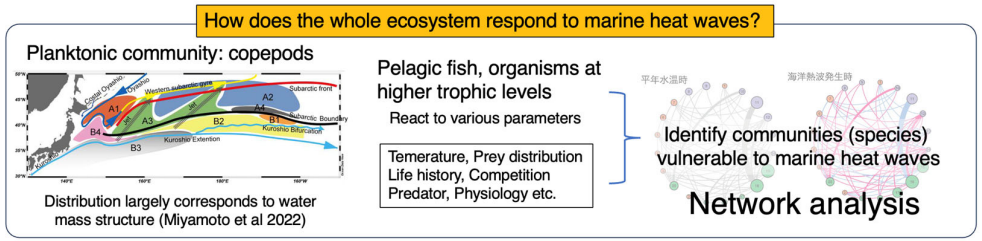

Figure 3: Diagram of example presentation of evaluation results

●Quantitative understanding of the effects of marine heat waves on key species

1) Development of novel fisheries stock estimation

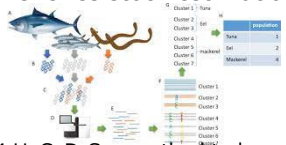

Figure 4 HaCeD-Seq method to be considered for application (Yoshitake et al. 2019).

2) Improved accuracy of models of harmful algal bloom

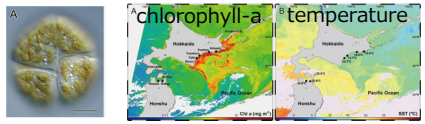

Figure 5 *Karenia seriformis* (left) and satellite images at the bloom occurrence (right)in Oct 2021 (Iwataki et al. 2022).

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