My Career of Plan Bs—Supported by the Kakenhi Program

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Research Themes Implemented in FY2017:
Change in lower trophic ecosystem and its complex mechanism in the North Pacific
Grant-in-Aid for Scientific Research on Innovative Areas (Research in a proposed research area)
Plankton in polar regions—toward an understanding of their characteristics (Grant-in-Aid for Scientific Research (S))

From 2002, the Kakenhi program extended its scope to include researchers based at research and development agencies—I applied right away. The title of my proposed research project was "Comparison of paleoenvironmental changes between both hemispheres." In the northern hemisphere, my research focused primarily on the subarctic in the northwestern North Pacific, including its marginal seas such as the Okhotsk Sea, while in the southern hemisphere, my measurements centered on the eastern South Pacific, primarily off the coast of Chile. This research involved collecting marine sediments and reconstruction of the marine surface environment at the geological time by performing a chemical analysis of the composition of substances such as carbonate microfossils and organic compound biomarkers. I remember how happy I was to learn that my first Kakenhi application had managed to gain approval.

In the field of oceanography, in order to achieve the desired research outcomes it is essential that research cruises are able to take place on schedule and that the desired samples/data are obtained. The ship-time for conducting research cruises is fixed, and in the worst case scenario, the occurrence of bad weather such as low atmospheric pressure or a typhoon during this period can mean failure to obtain the planned observations and achieve any meaningful findings. As such, we always prepare multiple observation plans before we set sail to ensure that we can turn to Plan B or C should Plan A go awry. This allows us to remain calm and switch our observations to the next plan in the case of a problem, ensuring that we generate sound research findings during our limited ship-time.

I believe the depth of generosity of the Kakenhi program is evident in the fact that it

accommodates researchers' Plan B. For example, through to the FY2017 round of grants (FY2016 application), the section of the application procedures that details how to fill out the Research Plan and Methods column instructs applicants that "The plan and methods should indicate measures through consideration from multiple aspects, such as the action in the event that the research does not progress as originally planned." It is precisely this sentence that allows applicants to list measurement plans B and C, giving us the opportunity to push forward with our research—even if not necessarily under the original Plan A. I cannot overstate the extent to which this clause has saved my research!

For example, during the aforementioned Kakenhi-funded research into "Comparison of paleoenvironmental changes between both hemispheres," our original plan was to cruise the area south of 50°S offshore of Chile in order to collect marine sediments in the research vessel (R/V) *Mirai*. However, we encountered a massive low pressure front, forcing the R/V *Mirai* to retreat to the Magellan Strait. Due to repeated low atmospheric pressures we found ourselves approaching our time limit without once having been able to enter the offshore Southern Ocean. We reverted to plan B, in which we collected marine sediment from a predetermined point on the Magellan Strait. The next Kakenhi grant I received for FY2007 was for research to identify "Changes in *Emiliania huxlyei* production recorded in surface sediment on the eastern continental shelf of the Bering Sea over the past 100 years" (this Kakenhi project planned to analyze the data gathered during a research cruise conducted in FY2006). Our Plan A for generating research findings involved conducting measurements in the Arctic Ocean. However, sea ice conditions that year were worse than anticipated, making it impossible for us to approach the Arctic Ocean. We were forced to switch to Plan B—an unprecedented change in plan that involved shifting our measurement area from the Arctic Ocean to an exact replica area spanning the north to the south region of the Bering Sea. However, this change turned out to be a success, unexpectedly allowing us to capture the large-scale bloom of *coccolithophorid*, *Emiliania huxlyei* in real time at the site. Regarding the bloom of *coccolithophorid*, whose levels had been rising in the Bering Sea in recent years but for which the underlying mechanisms were unknown, my research, coupled with marine sediment records over the past 100 years was successful in identifying that recent climate change also plays a part in this phenomenon in addition to the timing of the positive phase (warm in the Bering Sea) in the Pacific Decadal Oscillation that has occurred naturally in 20 to 30 year cycles. We took the step of announcing these findings in a press release. From FY2010, I subsequently embarked on a research project entitled "Catastrophic reduction of sea-ice in the Arctic Ocean—its impact on the marine ecosystems in the polar region," which aimed to identify the effect of recent declines in sea ice on the

productivity and composition of marine organisms. The key to our observation was the deployment of time-series sediment trap mooring systems in the Arctic Ocean to capture the biogenic particles synthesized by phytoplankton and zooplankton on the surface—known as "marine snow"—as well as the fragments or aggregates of fragments of the aforementioned particles that precipitate to deep sea. After collecting a time-series of samples over a one-year period, these sediment traps were to be recovered and biogenic particles collected in sediment traps were analyzed using a range of chemical and genetic techniques as well as a microscopic observation to identify the organism communities comprising the particles. However, the project hit a hurdle at the first step. Our proposed survey area was covered by sea ice, preventing us from deploying sediment trap mooring systems at our first-choice location. We hurriedly shifted to Plan B, which involved deploying the traps at the westernmost edge of the Canada Basin. After recovering the traps the following year, we conducted the aforementioned scientific analysis of the particles and interpretation of the biological communities, and conducted further analysis by incorporating the results of model simulations coupling a sea ice-physical oceanography model and an ecosystem model. These findings elucidated related mechanisms, namely that the sea ice reduction in Arctic coastal areas in recent years served to increase the volume of mesoscale eddies, and that the nutrients transported from deep to surface areas within these eddies stimulated primary and secondary productivity in the eddy. These findings were announced in 2014 in *Nature*'s sister publication and also as a press release.

Looking back over the series of observational research projects I have conducted with the support of the Kakenhi program brought me to the realization that not once have I managed to successfully complete Plan A. While this of course emphasizes the fact that research involving nature is tough and does not proceed according to plan, it also illustrates the fact that Kakenhi support for Plan B can lead to some unexpected findings—some of which are noteworthy enough to warrant press releases. The Kakenhi system and designated Procedures for Preparing and Entering Application Information undergo revisions as the era changes, and the details to be described in the research plan are, in fact, up for review in the lead-up to the release of the application guidelines for the FY2018 round of grants (FY2017 application). However, it is my earnest request that the program maintains the spirit of generosity that allows researchers to continue their research despite unforeseen circumstances.