Emergency Ocean Surface Environment Monitoring Study of Marine Driftage arising from the 2011 Great East Japan Earthquake

Report

March 2014

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

1. Purpose of Program

This program aims to estimate the locations and amount of the driftage that had been adrift in the sea at specific times after the Great East Japan Earthquake. The potential locations of these materials, referred to as “marine driftage,” were determined using numerical simulation to provide accurate information to related nations for estimating the scope of the marine driftage expected to be washed ashore both in Japan and other countries under similar conditions.

The program goals in the fiscal year were to quantitatively estimate marine driftage at certain times and locations, refined from that in the program of the previous fiscal year, and to estimate locations in the long term to understand the behavior of marine driftage in the future.

An experts’ meeting with related nations was also planned to share information and exchange opinions based on the results of current research.

2. Scope of Activities

Research projects were conducted as described below to assess the conditions, such as time, date, location, quantity, and category, of marine driftage resulting from the Great East Japan Earthquake using numerical simulation.

The results of the “Emergency Ocean-Surface Environmental Monitoring and Drift Simulation of Marine Debris arising from the 2011 Great East Japan Earthquake”(FY 2012 Program) were used in the current program in addition to the eddy-resolving ocean three-dimensional variational data assimilation system (MOVE) of the Meteorological Research Institute (MRI) for the short-term estimation of high-resolution ocean surface currents, and the atmosphere–ocean coupled four-dimensional variational data assimilation system (K7) developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) for the long-term estimation of the atmosphere and ocean system.

The following topics were included in the program for this fiscal year:

1. Marine driftage simulation

The motion of marine driftage for three years beginning in October 2013 was predicted under conditions (1) to (5) using assimilation data up to September 2013 and the method developed in the FY 2012 Program.

(1) Category of marine driftage

The calculations are based on the value of the following quantity: volume of driftage below the water surface:above the water surface = 1:0 or 1:1.

(2) Wind conditions used to calculate particle drift

Data was updated every six hours for the short-term estimation of high-resolution simulation and daily for the long-term estimation, as applied in the FY 2012 Program.

(3) Assessment of degree of uncertainty in the prediction method

To consider the uncertainty in the prediction method, the ensemble average was determined from a number of prediction calculations for case (1) under Section 2.1.

(4) Initial marine driftage distribution

The amount of marine driftage released by prefectures, as estimated by the Ministry of the Environment, is used.

(5) Particle drifting calculation system

Calculations assumed that all particles reaching off the coast of the North American continent remain in the same locations.

2. Experts' meeting and general symposium

An experts' meeting and a general symposium was held to share information such as research results and to exchange opinions with experts and related organizations of North American nations that may be the destination of disaster-induced marine driftage, as well as to disseminate information to the public.

3. Summary of research results

(1) The passages, quantities, and additional data on marine driftage to date are summarized, including predictions based on the simulation results mentioned in Section 1.

(2) The results of the activities mentioned in Section 2 above are summarized.

(3) The research results for the three years are consolidated.

The results of activities in this program are reported in Chapter 3 below.

3. Simulation of Marine Driftage

In the research of the last fiscal year reported in the FY 2012 Program, the distribution of abundant marine driftage resulting from the Great East Japan Earthquake, up to June 2012, was reproduced using numerical simulation, and the distribution up to March 2015 was predicted. The results suggested that the marine driftage drifted eastward first by the Kuroshio extension and subtropical westerlies, and then was dispersed in southerly and northerly directions by the mesoscale variabilities following the Kuroshio extension and atmospheric disturbances. The marine driftage approaching the North American continent was predicted to be swept away to the southwest by the North Equatorial Current and trade winds. It was revealed that the time of arrival and specific locations in the North American continent varied depending on the type of marine driftage due to the various influences of the ocean wind. This program aims to provide reliable information on marine driftage by assessing the distribution for the coming three years by using fields of ocean current and ocean wind in the prediction calculation for the three years with a focus on the latest reanalyzed data up to September 2013.

Ocean-current and ocean-wind data from K7, ocean-current data from MOVE, and ocean-wind data computed by the JMA Climate Data Assimilation System (JCDAS) were used in this research, just as they were in the FY 2012 research.

The overall flow of the marine driftage predictive simulation is as follows: The coastal ocean areas from which abundant marine driftage had been washed out were identified by satellite image analysis performed by the Japan Aerospace Exploration Agency (JAXA). Using these areas as the initial drifting locations, the number of particles corresponding to the quantity of marine driftage washed out to the ocean, as estimated by the Ministry of the Environment, from the Iwate, Miyagi, and Fukushima prefectures were estimated. Marine driftage is more likely to travel eastward in the Pacific Ocean mainly due to the Kuroshio extension and is significantly affected by its associated mesoscale eddies. Thus, a marine driftage predictive simulation, known as the “analysis calculation,” was conducted using MOVE ocean-current data and JCDAS ocean-wind data for the period up to September 2013. Subsequently, according to the assumption that the influence of the mesoscale eddies would be less significant after marine driftage had passed the Kuroshio extension area, a drifting simulation using K7 ocean-current data and ocean-wind data, known as the “prediction calculation,” was conducted for the period until September 2016 with the final field of the above analysis calculation as the initial condition. The marine driftage was also subjected to ensemble prediction calculation using ocean-current and ocean-wind data from the ensemble prediction in K7, to confirm the accuracy of the marine driftage prediction.

This chapter describes the calculation conditions and results of the behavior of marine driftage resulting from the Great East Japan Earthquake. The three-dimensional Ocean Dispersion Model (SEA-GEARN) developed by Japan Atomic Energy Agency (JAEA) was used to simulate the marine driftage. SEA-GEARN is a particle-dispersion model that simulates a number of particles as substances in the ocean to calculate their passages. The advection process was considered based on ocean-current data calculated using the ocean general circulation model, and the dispersion process was calculated using the random walk method (Kobayashi et al., 2007).

3.1 Data on Oceanographic and Meteorological Phenomena

During the period after the Great East Japan Earthquake from March 2011 to June 2012, ocean-current data from MOVE and ocean-wind data from JCDAS were used as inputs to SEA-GEARN. MOVE is an oceanographic data assimilation system developed by the MRI (Usui et al., 2006) that uses the analysis data calculated for the Northwest Pacific Ocean version (MOVE-WNP) and North Pacific Ocean version (MOVE-NP). The model region of MOVE-WNP is the Northwest Pacific Ocean north of Lat. 15 degree N. and west of Long. 160 degree W., and the horizontal resolution is one-tenth degree in both the east–west and north–south directions in regions near Japan and one-sixth degree north of Lat. 50 degree N. and east of Long. 160 degree E. The model region of MOVE-NP is the North Pacific Ocean north of Lat. 15 degree S., and the horizontal resolution is one-half degree in both east–west and south–north directions. 54 levels are set in both MOVE-WNP and MOVE-NP in the vertical direction. The layer thickness is 1 m at the first layer and 600 m at the deepest layer, and the vertical resolution at the ocean surface layer is set extremely high. In this program, the horizontal current speed data at layers 1 to 5 were vertically averaged to eliminate the influence of the local wind current from MOVE ocean-current data, and this value was used as an input to SEA-GEARN for calculating the local wind current from the ocean-wind data. The ocean wind data from JCDAS is an external force data obtained by driving MOVE, which was used to calculate the local wind current and leeway in this program. In the marine driftage predictive simulation, MOVE ocean-current data was updated daily, and JCDAS ocean-wind data was updated every six hours.

For the period from October 2013 to September 2016, ocean-current data and ocean-wind data calculated by K7 were used as inputs to SEA-GEARN. K7 was developed by JAMSTEC, and the atmosphere and ocean coupled data assimilation system (Sugiura et al., 2008) consists of the Atmospheric General Circulation Model for the Earth Simulator (AFES) and the Ocean-Sea Ice General Circulation Model for the Earth Simulator (OIFES). The AFES is provided with a horizontal resolution of approximately 3 degree and 24 levels in the vertical direction. OIFES is provided with a horizontal resolution of 1 degree and 45 levels in the vertical direction. In the marine driftage predictive simulation, ocean-current data for an average of 10 days calculated by K7 and ocean-wind data for one day were entered.

3.2 Types of Marine Driftage

The lumber of damaged houses and other structures is considered the major marine driftage washed out by the Great East Japan Earthquake; however, the inclusion of many other types of driftage such as floats and plastic products used for aquaculture and set net fisheries is also considered. The behavior of marine driftage is significantly affected by the ocean current and ocean wind. Because the influence of the ocean wind depends on the volume of marine driftage that floats on the water surface, the marine driftage was classified according to the ratio of volume above and below the water surface, as shown below:

(1) Marine driftage below the water surface (entirely submerged): All parts are underwater. Lumber containing significant water falls into this category. The marine driftage in this category is hardly affected by leeway.

(2) Standard marine driftage (volume of the driftage above the water surface:below the water surface = 1:1): Marine driftage with virtually equal volumes above and below the water surface, such as the lumber of damaged houses and other structures, and sunken fishing boats. The majority of marine driftage is considered to fall into this category.

In the marine driftage predictive simulation performed in this program, the influences of ocean current, local wind current, and leeway are considered. Ocean current and local wind current exert similar influences on the two aforementioned types of marine driftage, although the influence of leeway differs depending on the type of marine driftage. Specifically, leeway ($\vec{v}_w$) is given by the following formula in the marine driftage predictive simulation:

$$\vec{v}_w = k\sqrt{\frac{A}{B}} \times \vec{W}_{10},$$

where k is the wind pressure coefficient; A and B are the volumes of marine driftage above and below the water surface, respectively; and $\vec{W}_{10}$ the wind velocity at 10 m above the sea. The wind pressure coefficient value was set based on data provided by the Japan Coast Guard.

3.3 Calculation Conditions

In the analysis calculation, the temporal resolution of SEA-GEARN was 360 seconds, and the spatial resolution was one-tenth degree in both east–west and south–north directions. Conversely, the temporal resolution was 3600 seconds, and the spatial resolution was 1 degree in both east–west and south–north directions in the forecast calculation. In addition, the horizontal diffusion coefficient in the analysis calculation was 5.0×10^5 cm^2/s, whereas that in the forecast calculation was set at 5.0×10^6 cm^2/s. Vertical motion of the marine driftage was not considered in this program, and advection current and diffusion in the vertical direction were ignored. The marine driftage behavior in two-dimensional fields, or east–west and south–north directions, was calculated.

The initial release marine driftage condition was set as follows:

Regarding the sea area for release, areas off Iwate, Miyagi, and Fukushima prefectures were determined from the results of analysis images from the advanced DAICHI land-observing satellite by JAXA, in which abundant marine driftage was found and released from three points off these prefectures, as shown in Table 1. Regarding the volume of released marine driftage, the number of particles corresponding to the quantity of marine driftage washed out from these prefectures as estimated by the Ministry of the Environment and shown in Table 1 was released with one particle representing 10 tons of marine driftage. For example, 699,000 particles were released from Iwate Prefecture for an estimated 69,900 tons of marine driftage.

The marine driftage reaching off the coast was assumed to remain in the same location in the simulation. The current field of the coastal region is affected by complicated shorelines and steeply inclined seabed topography, and the influence of tide and river flow is considered to be remarkable. The ocean wind is also known to be extremely complicated because it is affected by mountains on the land in coastal regions. With the temporal and spatial resolutions set for the simulation in this research, the oceanographic and meteorological phenomena in the coastal regions may not be represented accurately. Therefore, special attention should be paid to the calculation results for coastal regions.

Table 1 Initial release conditions for marine driftage in the predictive simulation.
Longitude and latitude indicate the release points of marine driftage off these prefectures. The amounts of release were estimated by the Ministry of the Environment.

	1	2	3	Total
Prefecture	Iwate	Miyagi	Fukushima	-
Latitude	39N	38N	37N	-
Longitude	143E	142E	142E	-
Outflow quantity (1,000 tons)	699	443	394	1536

3.4 Simulation Results

3.4.1 Analysis Calculation and Forecast Calculation

The distribution of marine driftage in July 2012 in the analysis calculation is shown for each of the two types of marine driftage (Figure 1). The colors of the marine driftage in the upper and middle images in the figure represent percentages of the number of particles in the computation grid (1/10 deg. × 1/10 deg.) against the total number of particles. The area in which the presence of marine driftage is comparatively low is represented in blue, whereas the areas more likely to contain marine driftage are indicated in red. At this time, marine driftage travels eastward in the Pacific Ocean due to the Kuroshio extension and westerly winds and is dispersed in southerly and northerly directions due to the mesoscale eddies associated with the

Kuroshio extension and atmospheric disturbances. Standard marine driftage travels eastward faster than the marine driftage below the water surface because of the comparatively large impact of the ocean wind. The figure shows that part of the standard marine driftage has already reached the west coast of the North American continent, although the marine driftage below the water surface reached only near the 140 degree W area. Figures 2 through 5 show the distributions of marine driftage from September 2012 to March 2013. The marine driftage below the water surface moved farther eastward in the North Pacific Ocean and approached 130 degree W at the west coast of the North American continent. The standard marine driftage traveled in a counterclockwise direction off the west coast of the North American continent, and a portion was swept away in the southwest direction while approaching the Hawaiian Islands. Figures 6 through 8 show the distribution of marine driftage from May 2013 to September 2013. The analysis calculation confirmed that the marine driftage below the water surface had not reached the west coast of the North American continent. It was revealed that the standard marine driftage off the west coast of the North American continent moved in a southwesterly direction and tended to migrate to the Hawaiian Islands.

Figures 9 through 12 show the distributions of marine driftage from November 2013 to May 2014 in the forecast calculation. Similar to that in the analysis calculation, the colors of the marine driftage represent percentages of the number of particles in the computation grid against the total number of particles. The spatial resolution of the forecast calculation is 1 degree. The percentage was, therefore, converted to that in the same computation grid as the analysis calculation by dividing the percentage of the number of particles in the computation grid for forecast calculation (1 deg. × 1 deg.) against the total number of particles by 100. The distribution of marine driftage in this period suggested movement below the water surface in the northeast direction to reach the west coast of the North American continent. The standard marine driftage also tended to move toward the northeast, suggesting arrival at the west coast of the North American continent. Both types of marine driftage were spread widely over a zonal area, stretching from the west coast of the North American continent to the Philippine islands, or in the North Pacific Ocean south of Lat. 10–20 degree N. Figures 13 through 15 show the distributions of marine driftage from July 2014 to November 2014, which confirms the southward movement along the west coast of the North American continent—which is likely due to the influence of the highly developed North Pacific in summer. Figures 16 through 26 show the distributions from January 2015 to September 2016, from which it was predicted that the zonal distribution of marine driftage below the water surface continued to increase and that the marine driftage gathered in the area of Lat. 30 degree N. and Long. 160 degree W. north of the Hawaiian Islands in September 2016. The standard marine driftage also spread in a zonal area in the southern part of the North Pacific Ocean, although its distribution was significantly broader than that of the marine driftage below the water surface due to the influence of the ocean wind. An area in which the standard marine driftage converges, such as that below the water surface, was not confirmed.

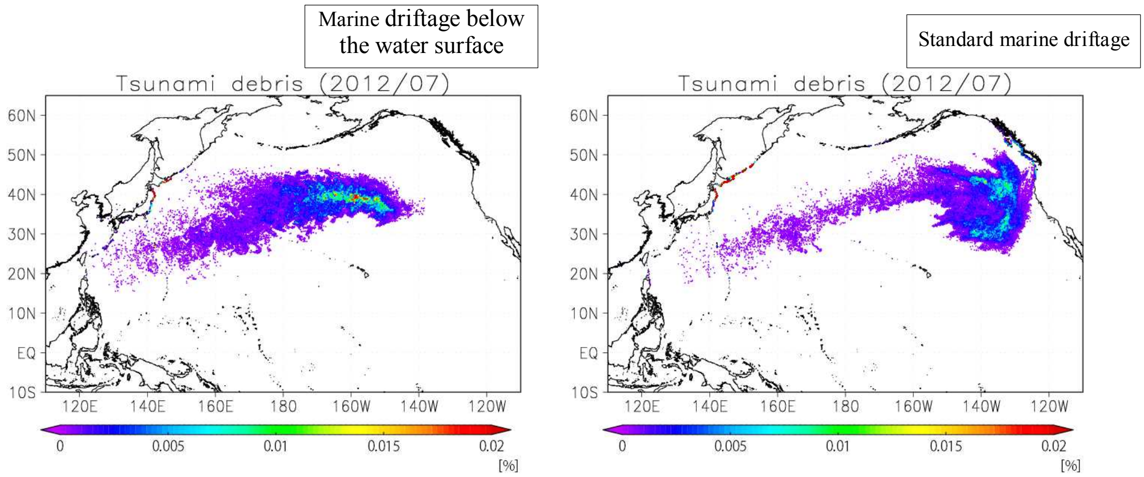

Figure 1 Distributions of marine driftage by type on July 15, 2012, as determined by analysis calculation. Colors represent the percentages of the number of particles in the computation grid against the total number of particles.

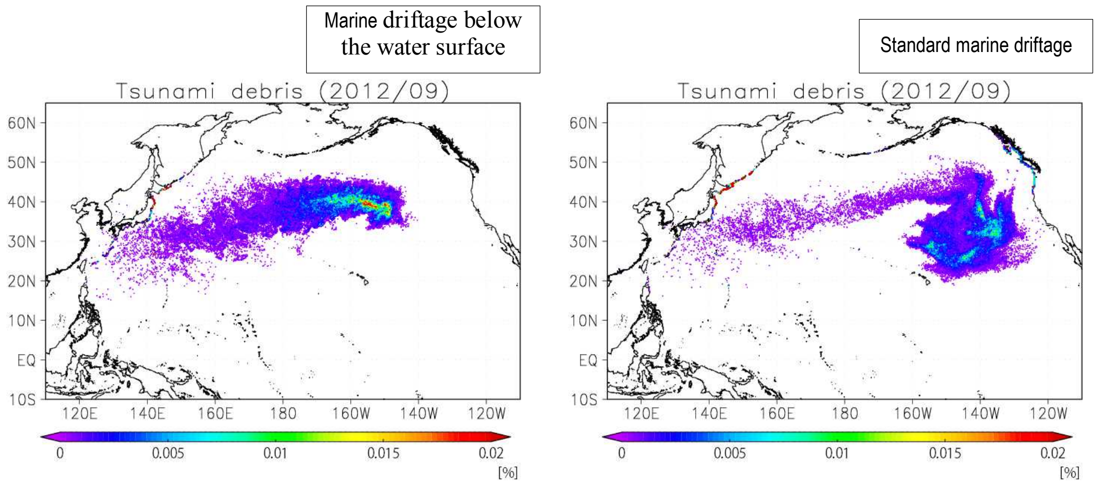

Figure 2 (Same as Figure 1) Distributions on September 15, 2012.

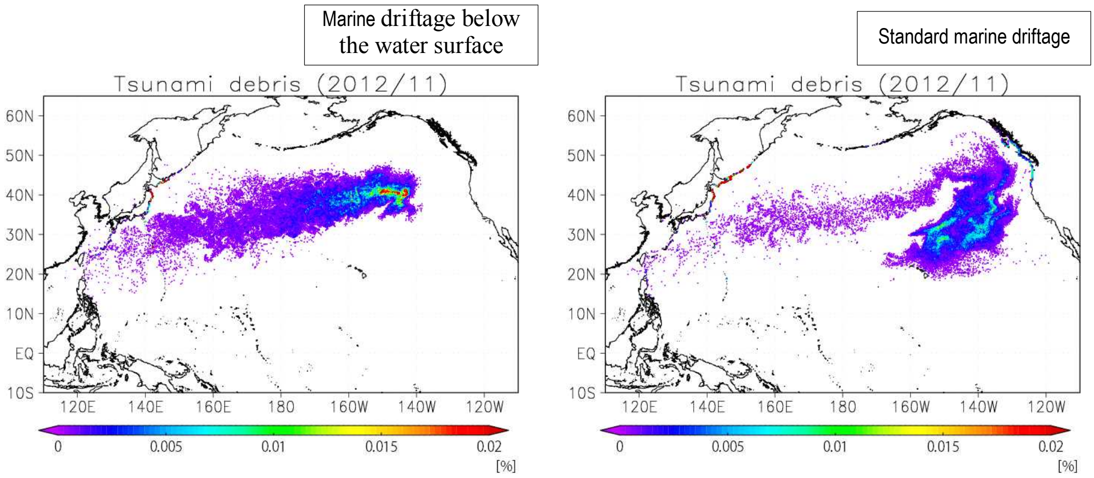

Figure 3 (Same as Figure 1) Distributions on November 15, 2012.

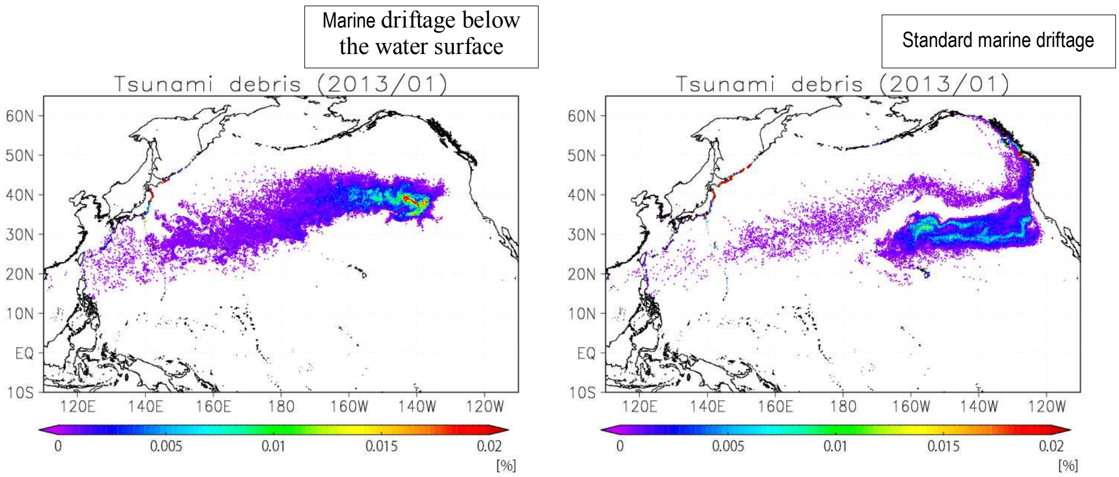

Figure 4 (Same as Figure 1) Distributions on January 15, 2013.

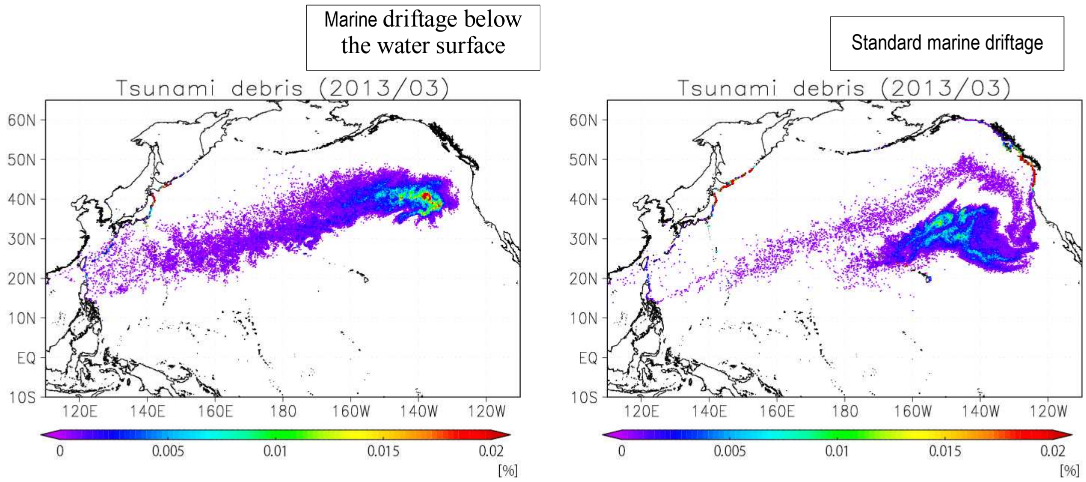

Figure 5 (Same as Figure 1) Distributions on March 15, 2013.

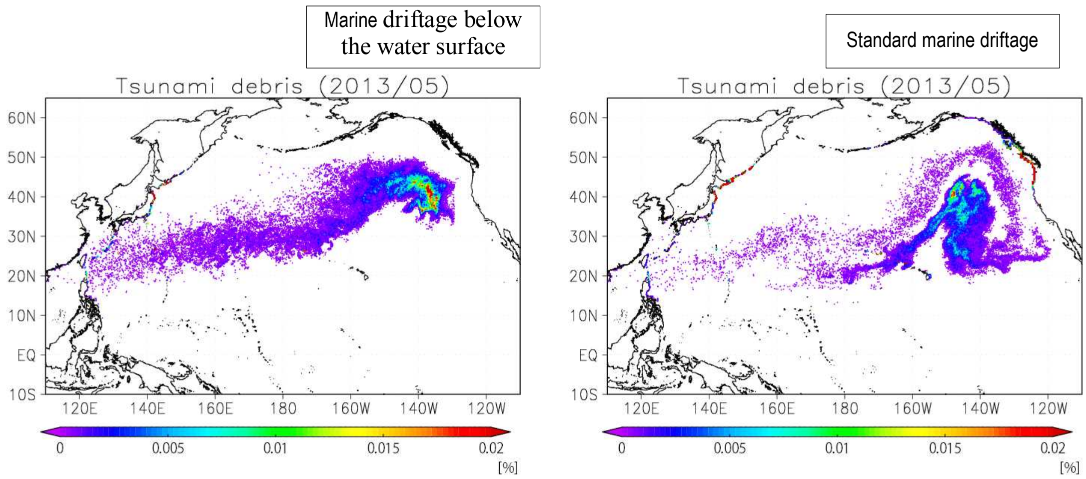

Figure 6 (Same as Figure 1) Distributions on May 15, 2013.

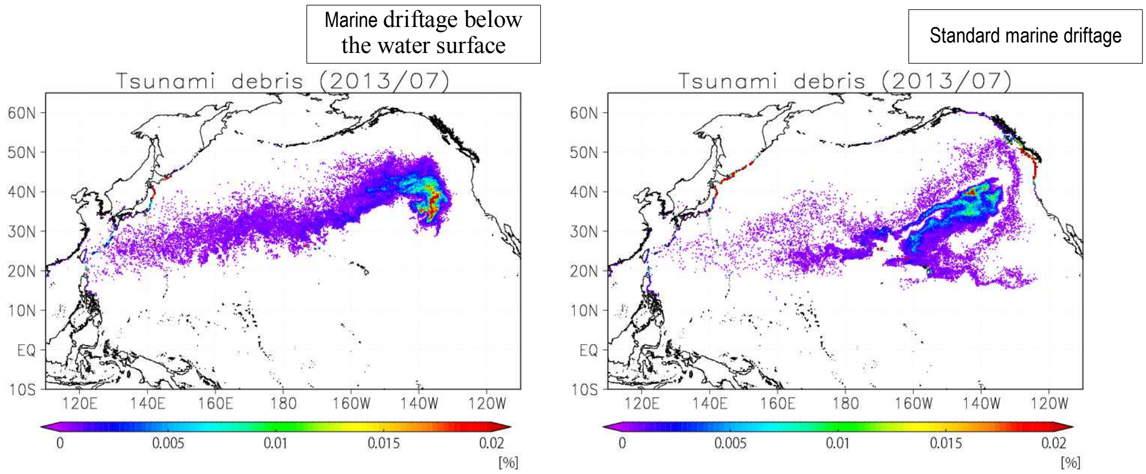

Figure 7 (Same as Figure 1) Distributions on July 15, 2013.

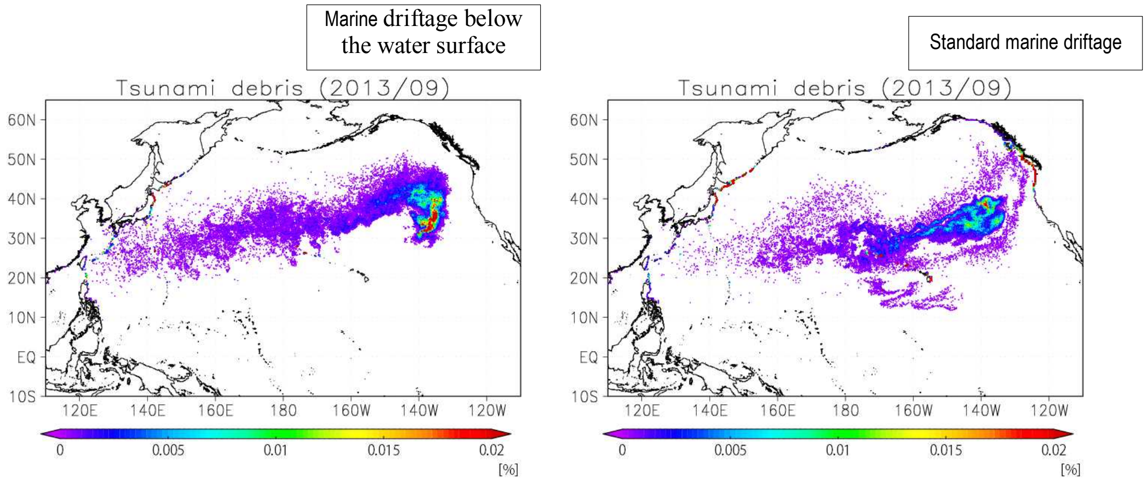

Figure 8 (Same as Figure 1) Distributions on September 15, 2013.

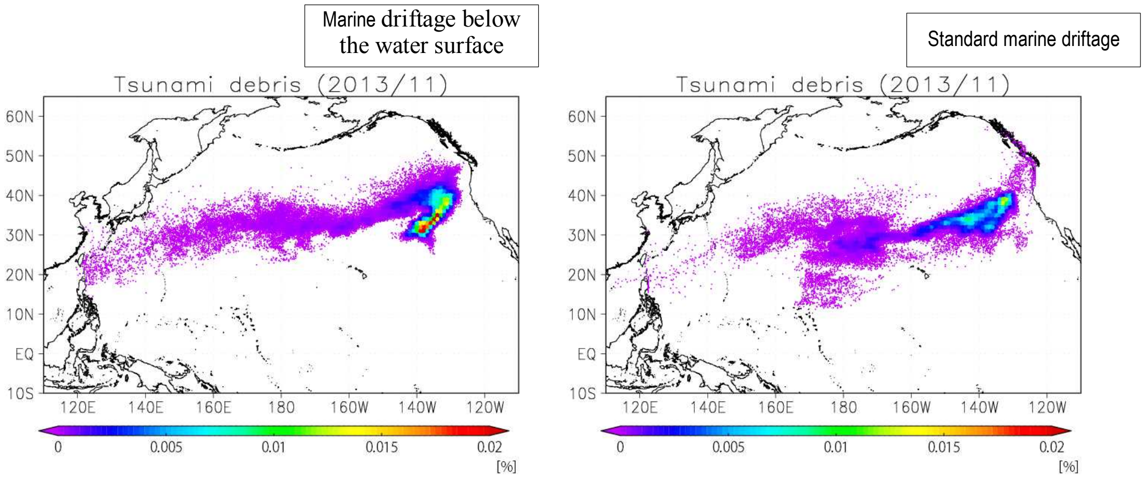

Figure 9 Distributions of marine driftage by type on November 15, 2013, as determined by the forecast calculation. Colors represent percentages of the number of particles in the computation grid against the total number of particles.

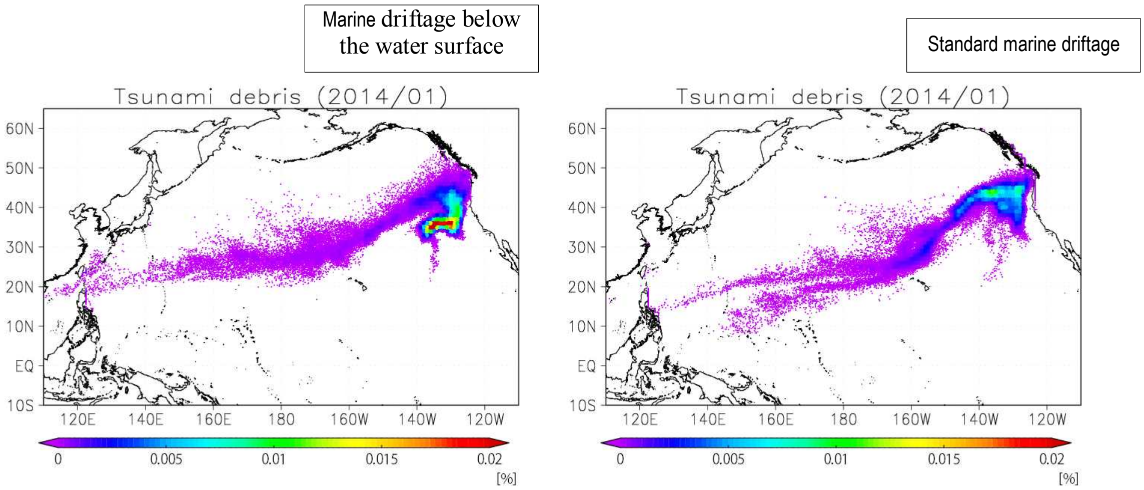

Figure 10 (Same as Figure 9) Distribution on January 15, 2014.

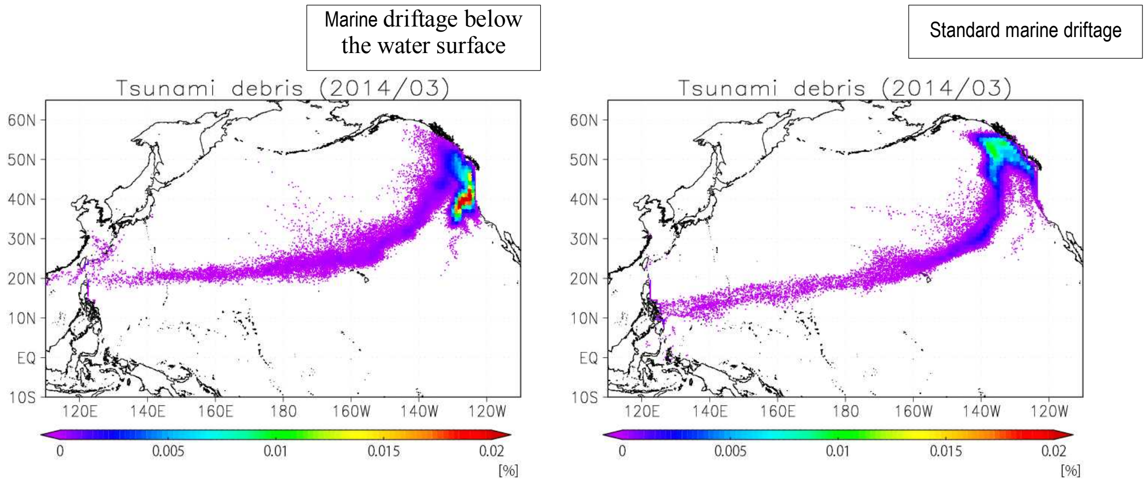

Figure 11 (Same as Figure 9) Distributions on March 15, 2014.

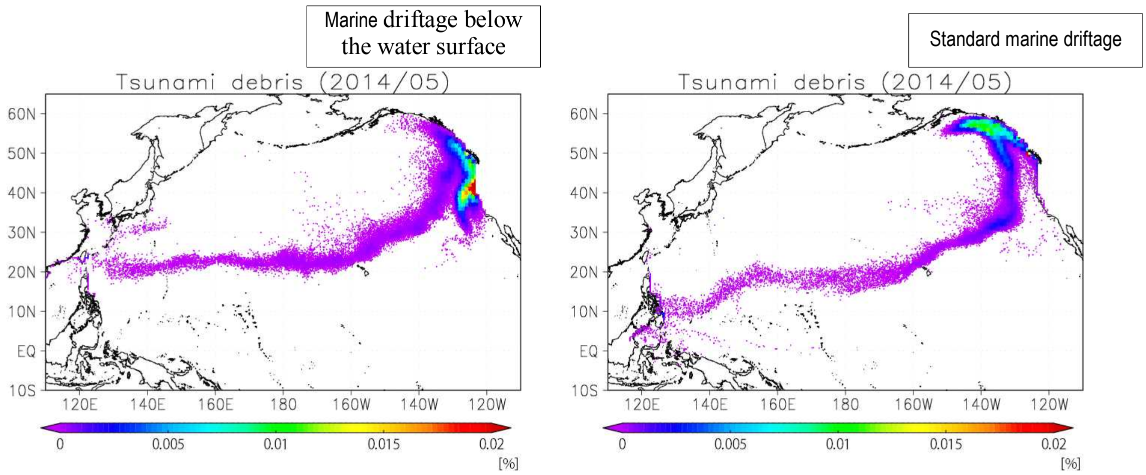

Figure 12 (Same as Figure 9) Distributions on May 15, 2014.

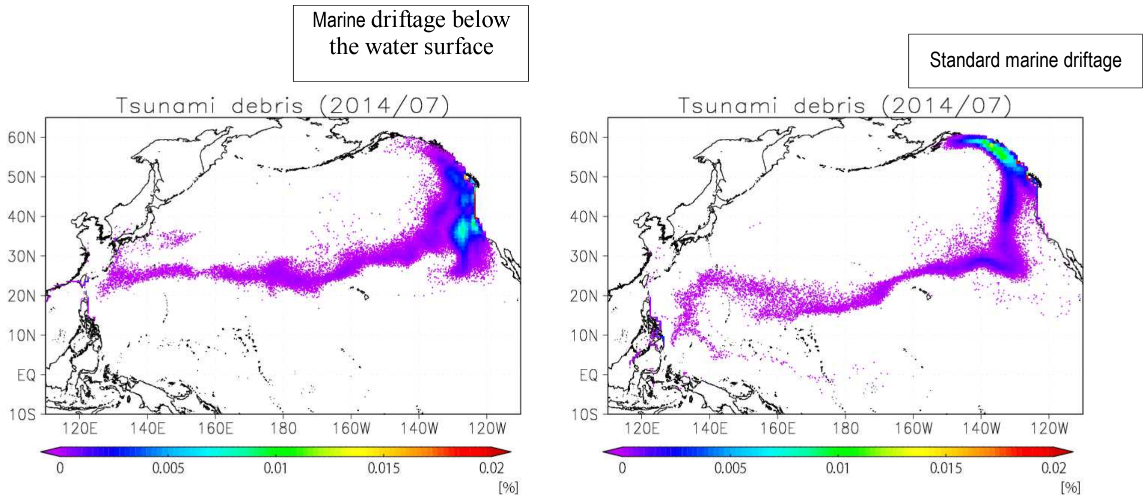

Figure 13 (Same as Figure 9) Distributions on July 15, 2014.

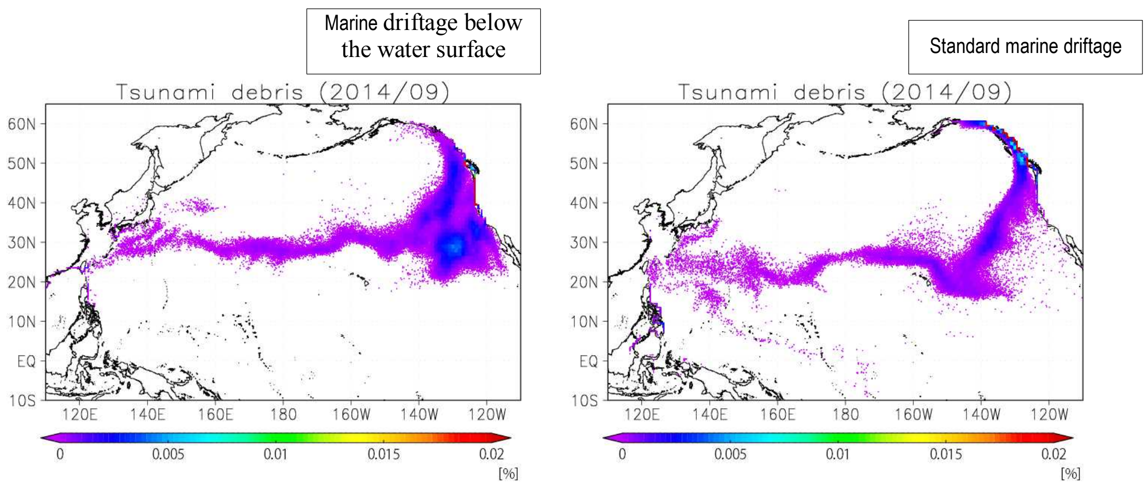

Figure 14 (Same as Figure 9) Distributions on September 15, 2014.

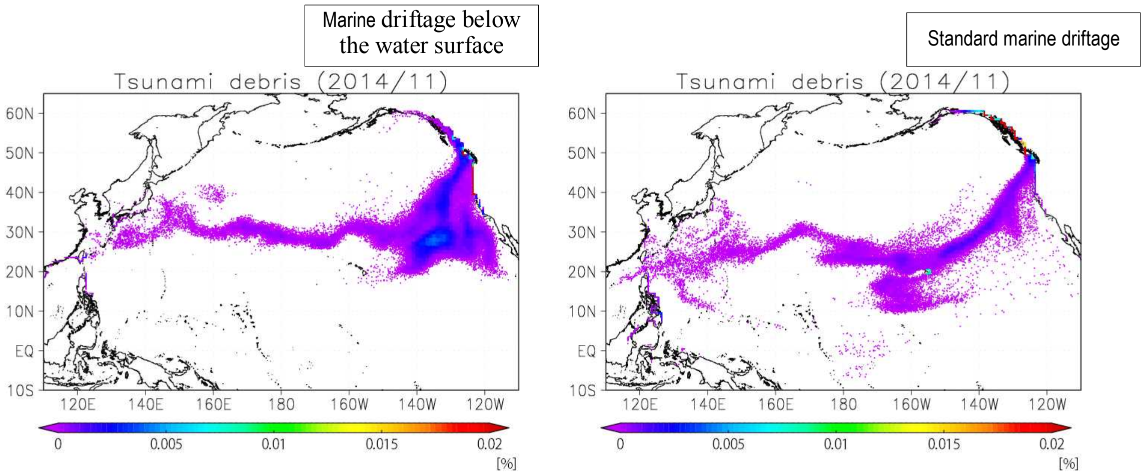

Figure 15 (Same as Figure 9) Distributions on November 15, 2014.

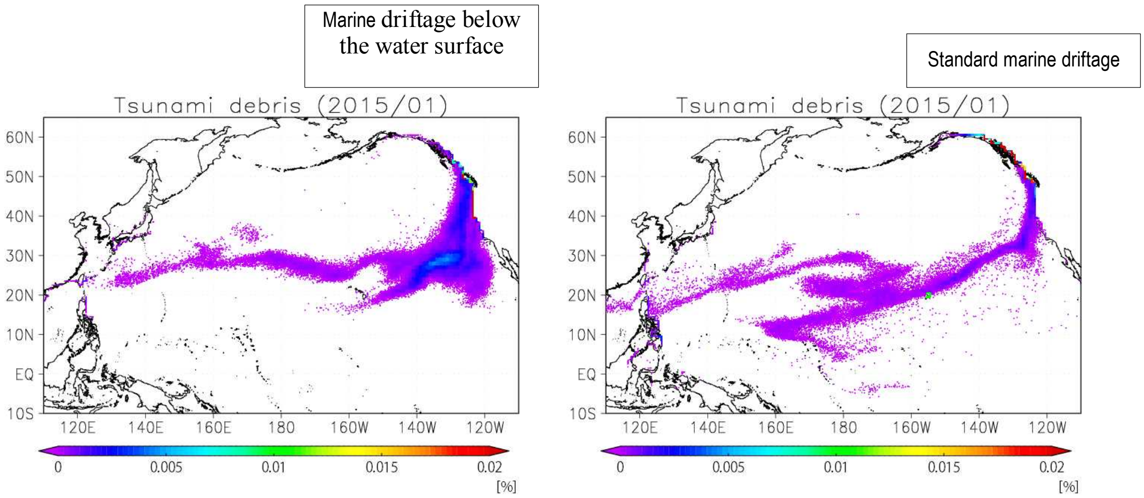

Figure 16 (Same as Figure 9) Distributions on January 15, 2015.

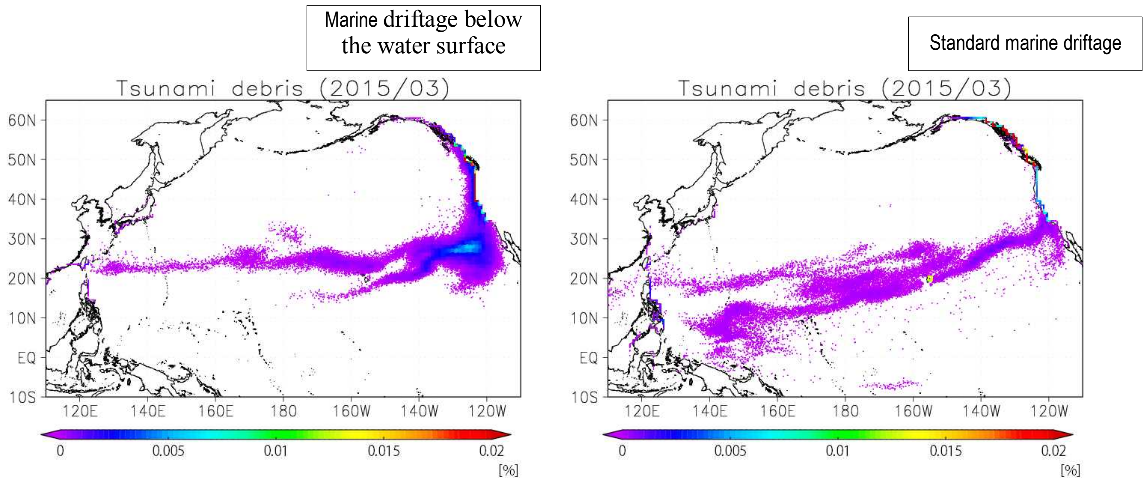

Figure 17 (Same as Figure 9) Distributions on March 15, 2015.

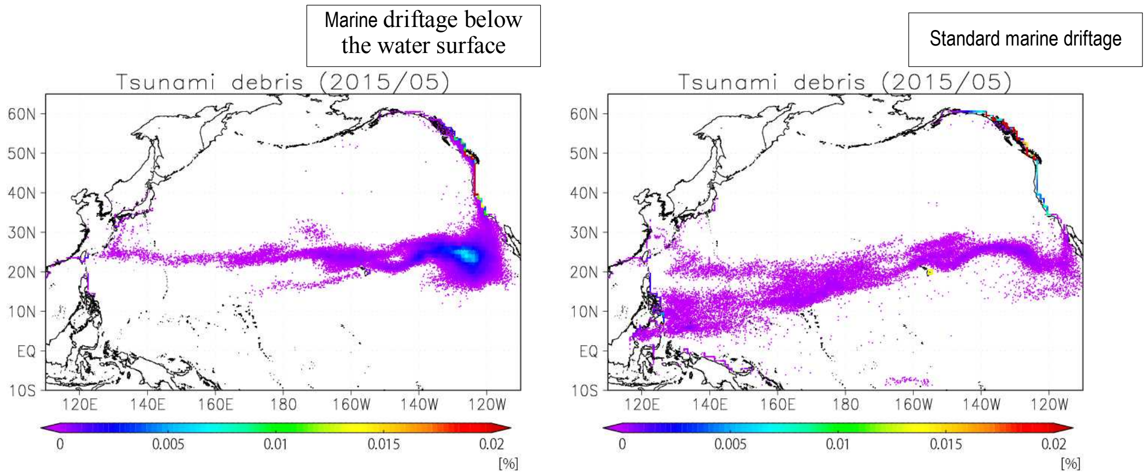

Figure 18 (Same as Figure 9) Distributions on May 15, 2015.

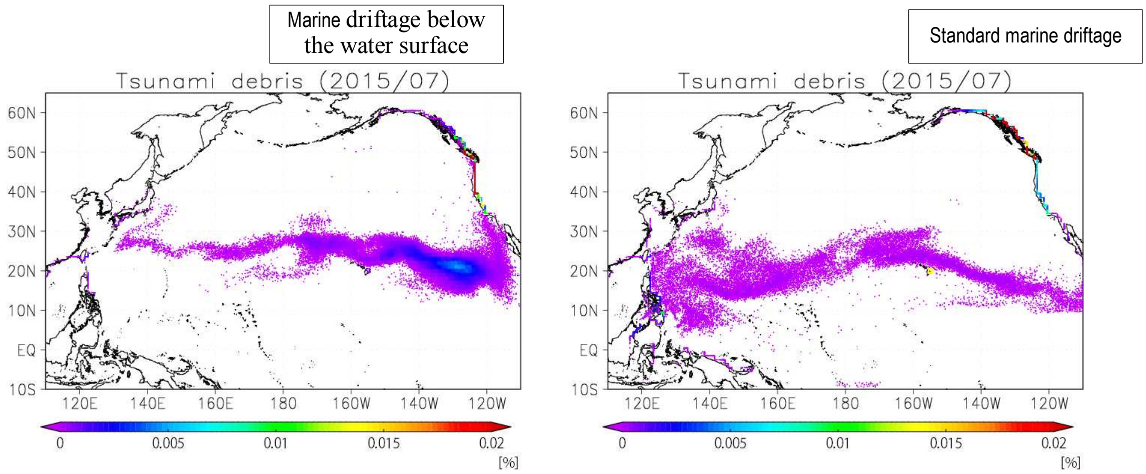

Figure 19 (Same as Figure 9) Distributions on July 15, 2015.

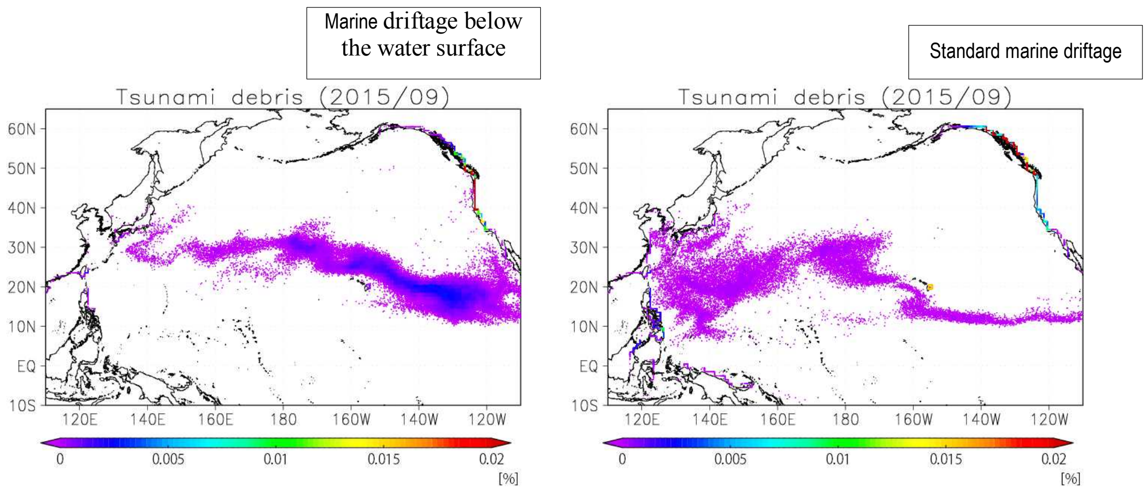

Figure 20 (Same as Figure 9) Distributions on September 15, 2015.

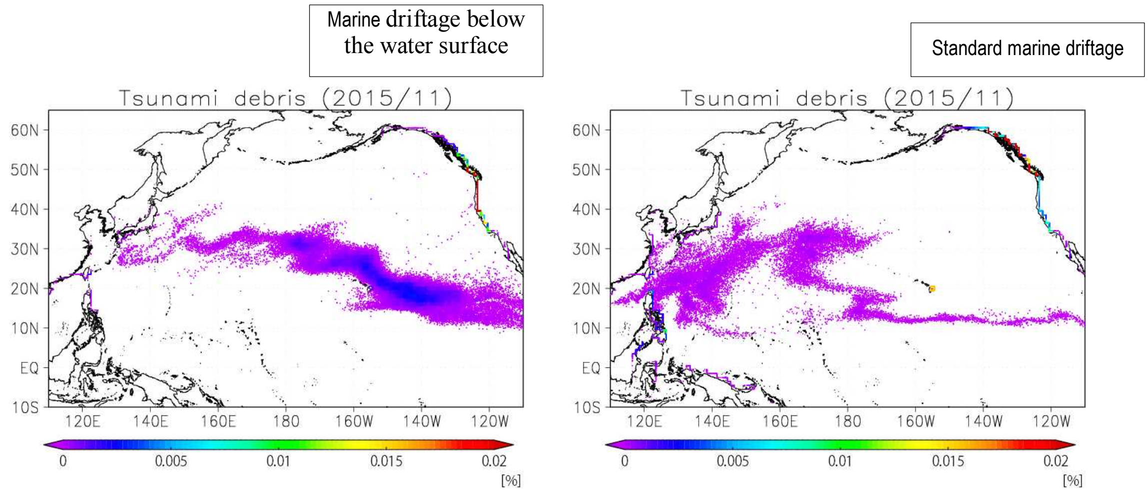

Figure 21 (Same as Figure 9) Distributions on November 15, 2015.

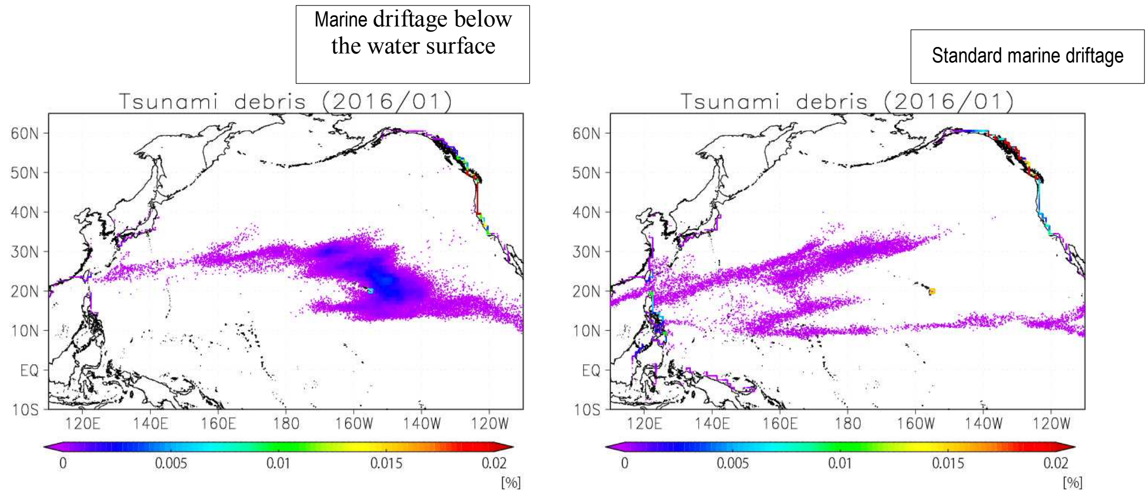

Figure 22 (Same as Figure 9) Distributions on January 15, 2016.

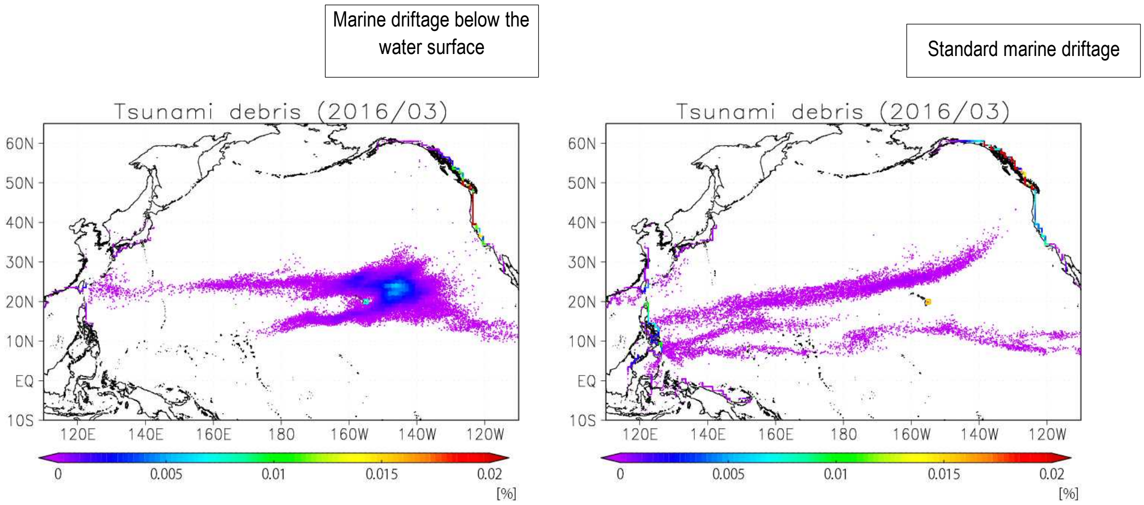

Figure 23 (Same as Figure 9) Distributions on March 15, 2016.

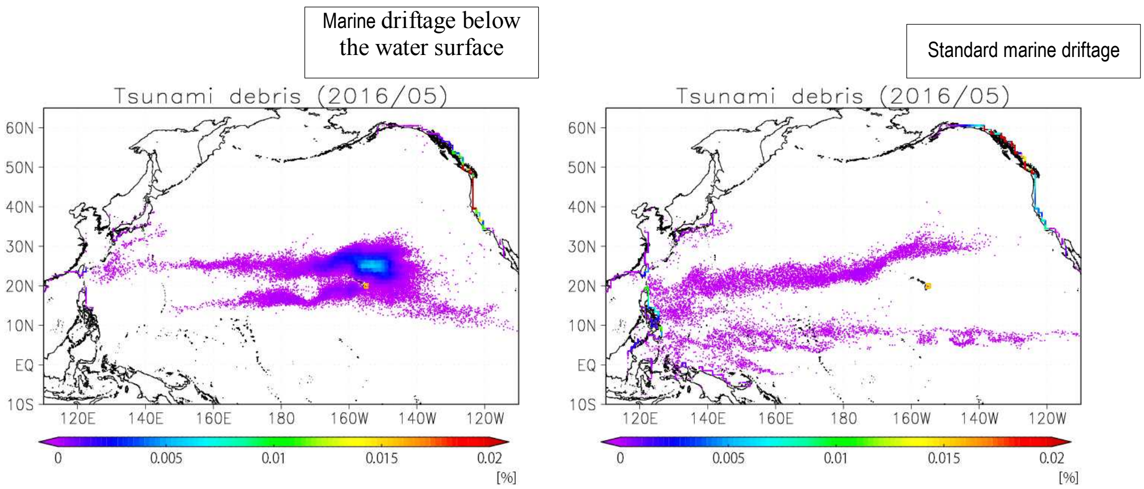

Figure 24 (Same as Figure 9) Distributions on May 15, 2016.

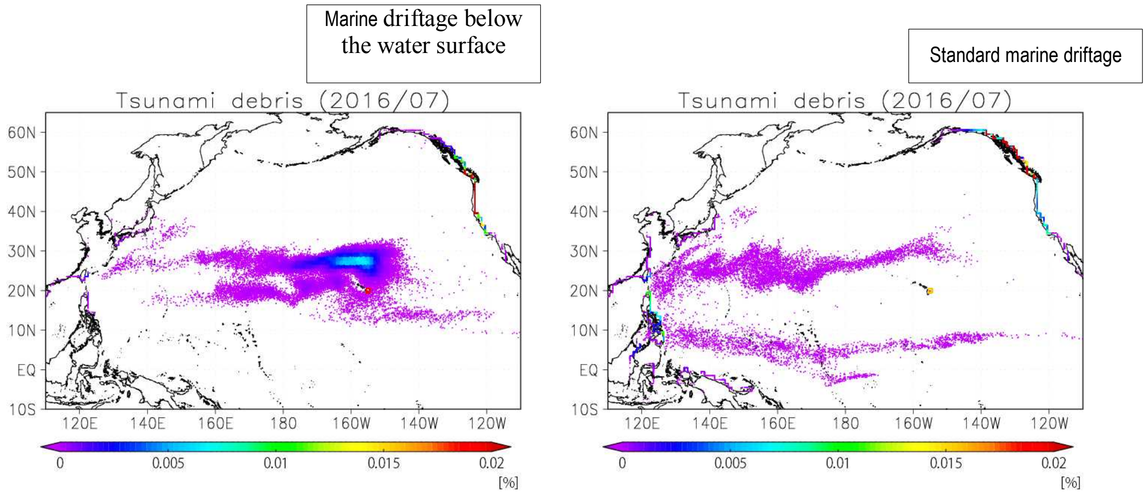

Figure 25 (Same as Figure 9) Distributions on July 15, 2016.

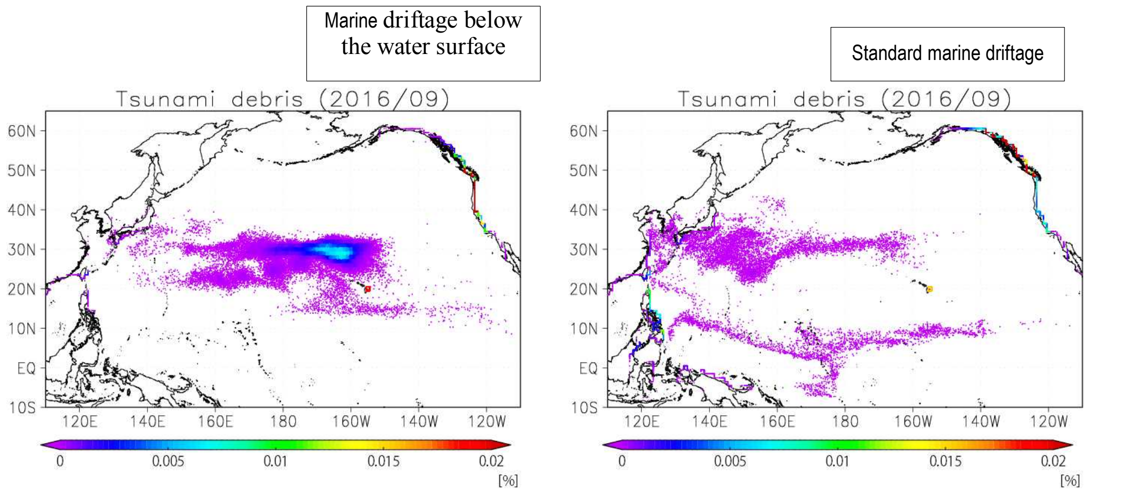

Figure 26 (Same as Figure 9) Distributions on September 15, 2016.

3.4.2 Ensemble Forecast Calculation

In the forecast calculation mentioned in 3.4.1, K7 ocean-current data and ocean-wind data were used with the results of data assimilation until September 2013 as the initial value. However, the accuracy of the forecast is uncertain, and its reliability cannot be confirmed, particularly with one type of forecast data. Therefore, based on this assimilation data, 11 members of the ensemble forecast calculation were conducted to create slight deviation in the initial values, and the distribution of marine driftage was computed more reliably using 11 types of K7 ocean-current and ocean-wind data. Similar to the forecast calculation in 3.4.1, with the final field of analysis calculation as the initial marine driftage condition, calculations were conducted up to September 2016 using 11 members of ocean-current and ocean-wind data.

Figure 27 shows the ensemble forecast calculation results for March 2015 and their average. The marine driftage below the water surface was subject to calculation. The 11 types of calculation results showed no significant differences in the overall distribution. However, differences were confirmed in the sea areas in which the marine driftage below the water surface may converge, which indicates the effectiveness of analyzing the average field from the 11 members of forecast results as a means of presenting more reliable forecasts than that by using a single forecast.

Figures 28 through 45 show the averages of the ensemble forecast calculations from November 2013 to September 2015. The marine driftage below the water surface is estimated to arrive in bulk at the west coast of the North American continent from 2014 onward, and it is suggested that the standard marine driftage also reached the west coast. The marine driftage off the west coast of North America still migrated northward in winter (Figure 30), and to southward in summer (Figure 33). These results are attributed to the Aleutian low, which develops in the North Pacific Ocean in winter, and to the North Pacific high, which develops in summer. After departing the west coast of North America, the marine driftage is estimated to move in a southwesterly direction and expand to a zonal distribution near the Philippine islands as the results of the North Equatorial current and trade wind. The distribution of the standard marine driftage, which is significantly affected by ocean wind, is estimated to include significantly wider areas in the North Pacific Ocean than that of the marine driftage below the water surface. Similar to that in the forecast calculation in 3.4.1, the marine driftage below the water surface is estimated to accumulate in the sea areas north of the Hawaiian Islands through the ensemble forecast calculation (Figure 45).

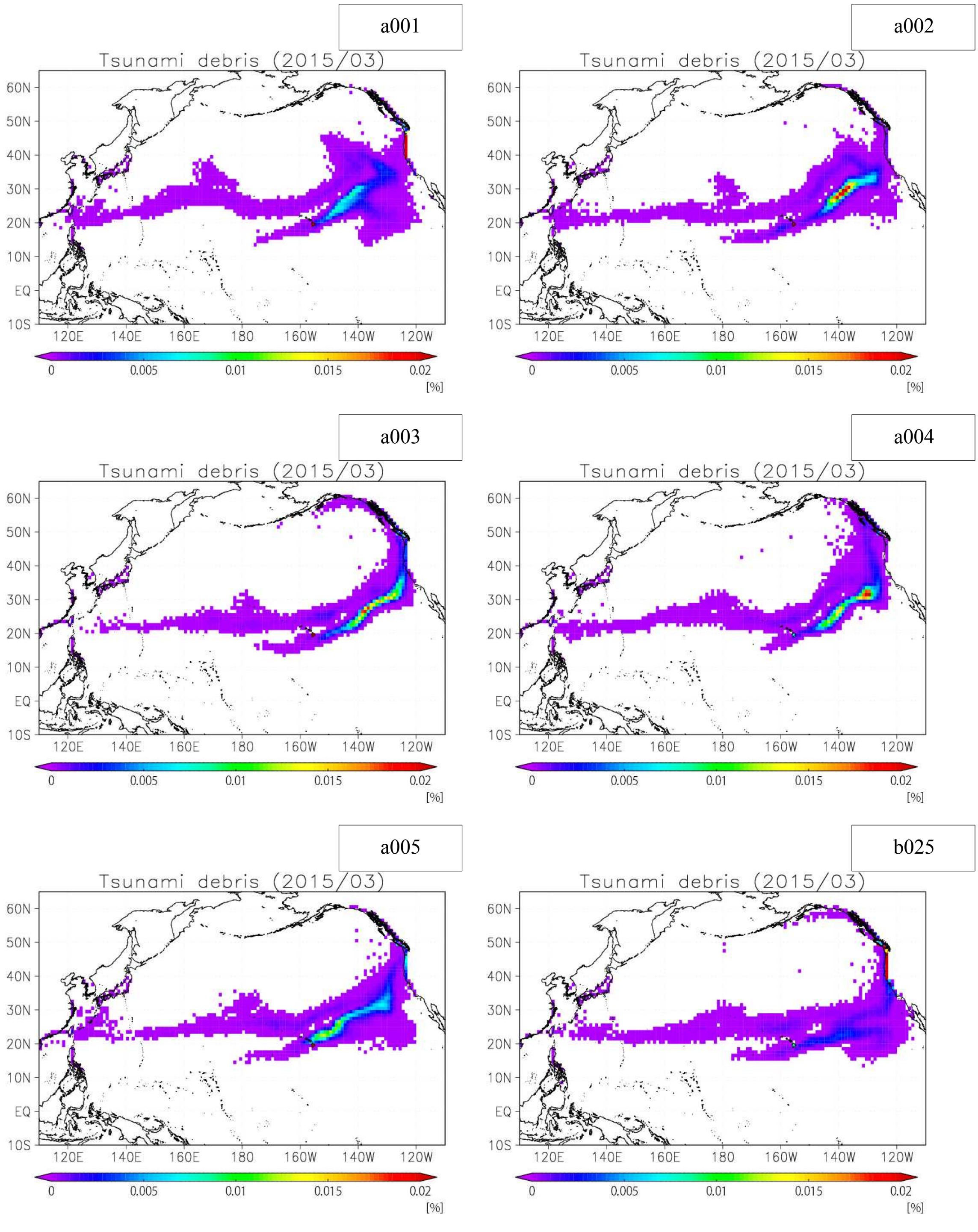

Figure 27a Results of the calculation of marine driftage below the water surface on March 15, 2015, using ensemble forecast data of ensemble members a001– b025. The distribution of marine driftage below the water surface is indicated in the computation grids by various colors.

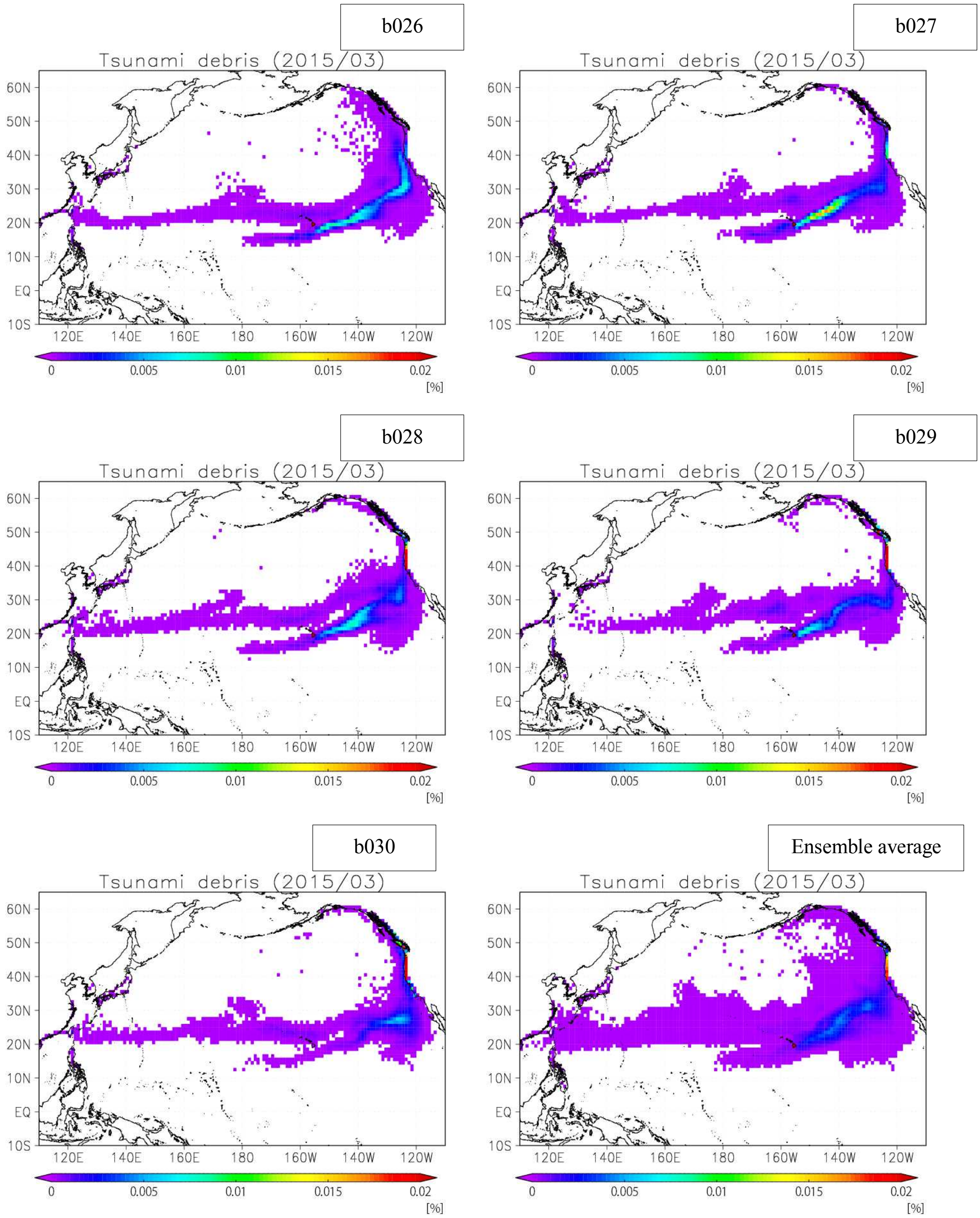

Figure 27b Results of the calculation of marine driftage below the water surface on March 15, 2015, using ensemble forecast data (b026–b030) and ensemble averages.

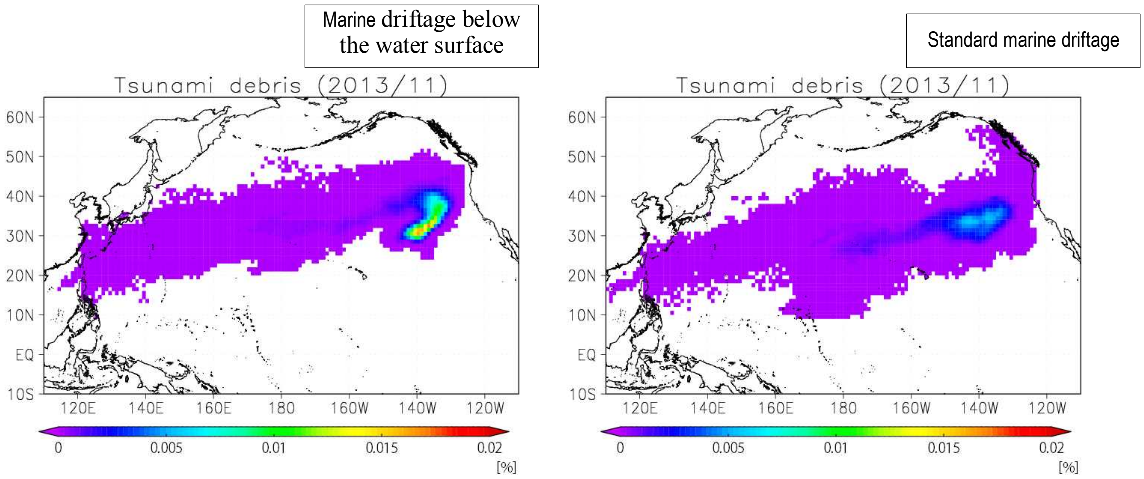

Figure 28 Average results of the ensemble forecast calculation on November 15, 2013. The distribution of marine driftage below the water surface is indicated with the computation grids in various colors.

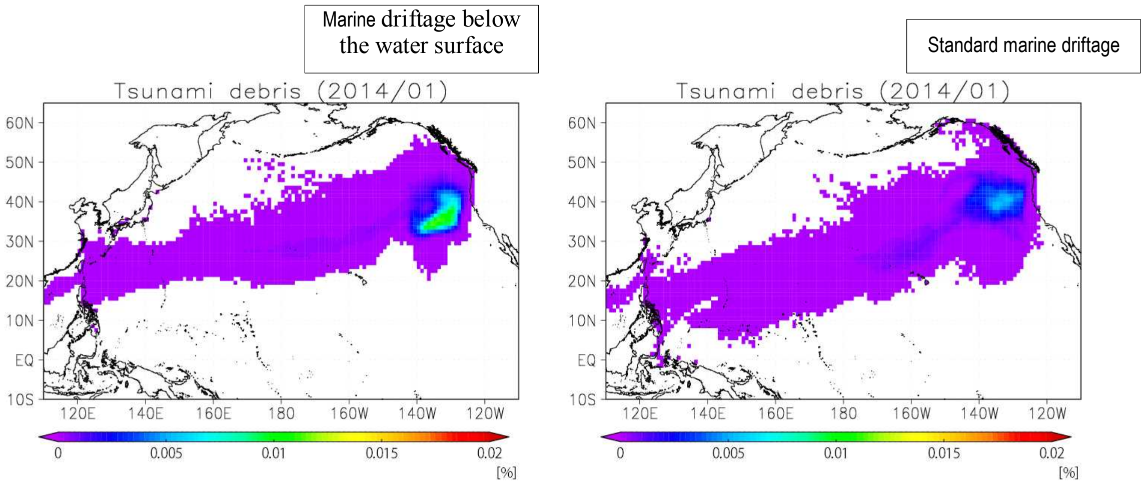

Figure 29 (Same as Figure 28) Distributions on January 15, 2014.

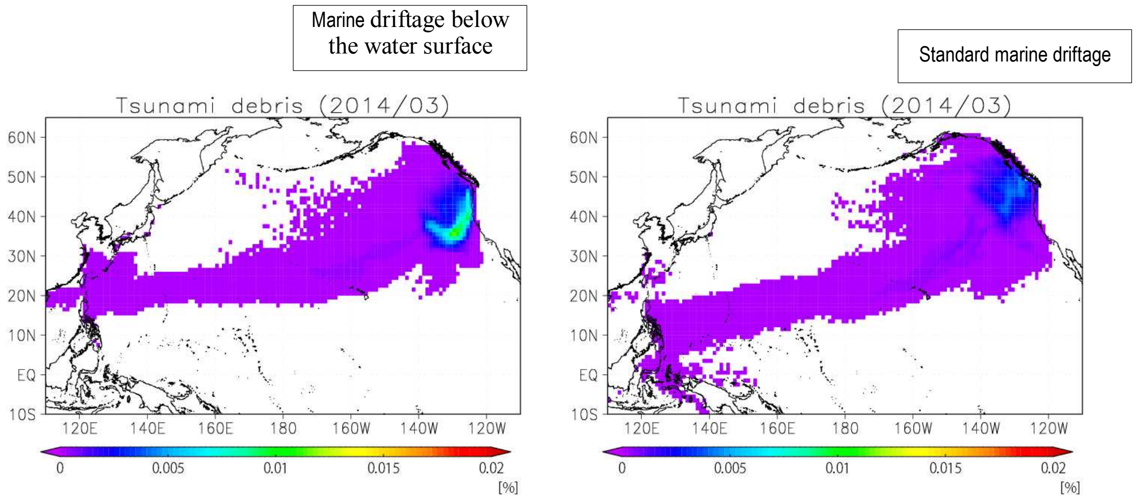

Figure 30 (Same as Figure 28) Distributions on March 15, 2014.

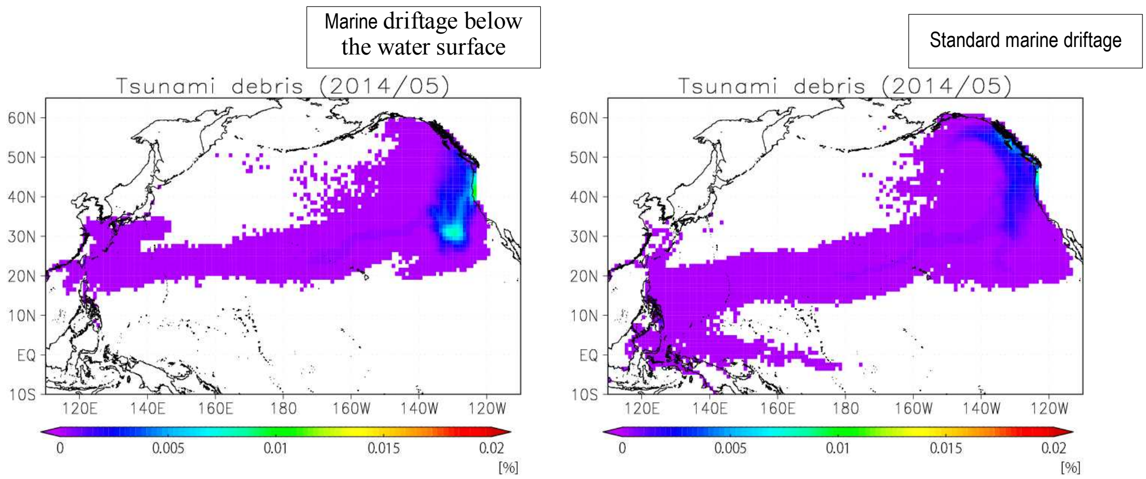

Figure 31 (Same as Figure 28) Distributions on May 15, 2014.

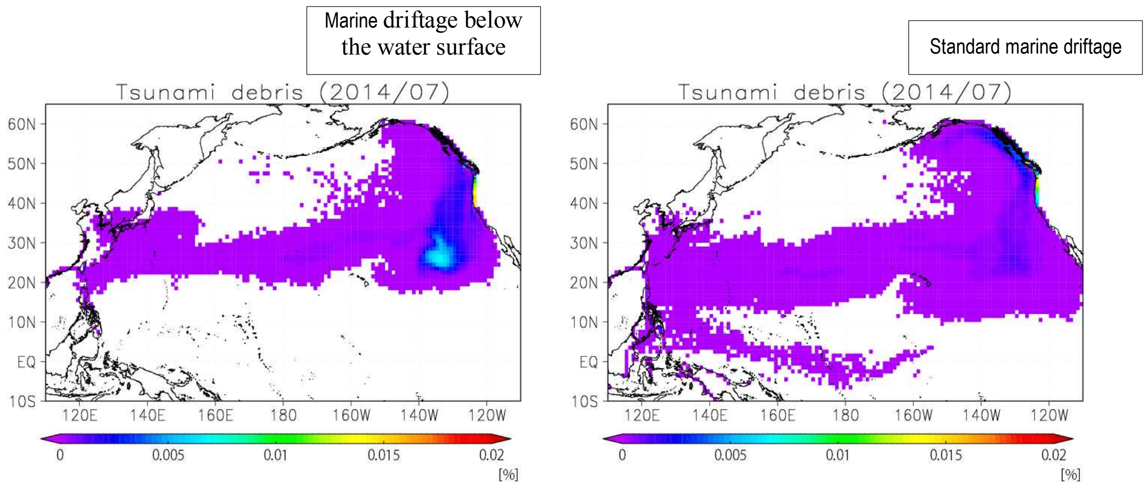

Figure 32 (Same as Figure 28) Distributions on July 15, 2014.

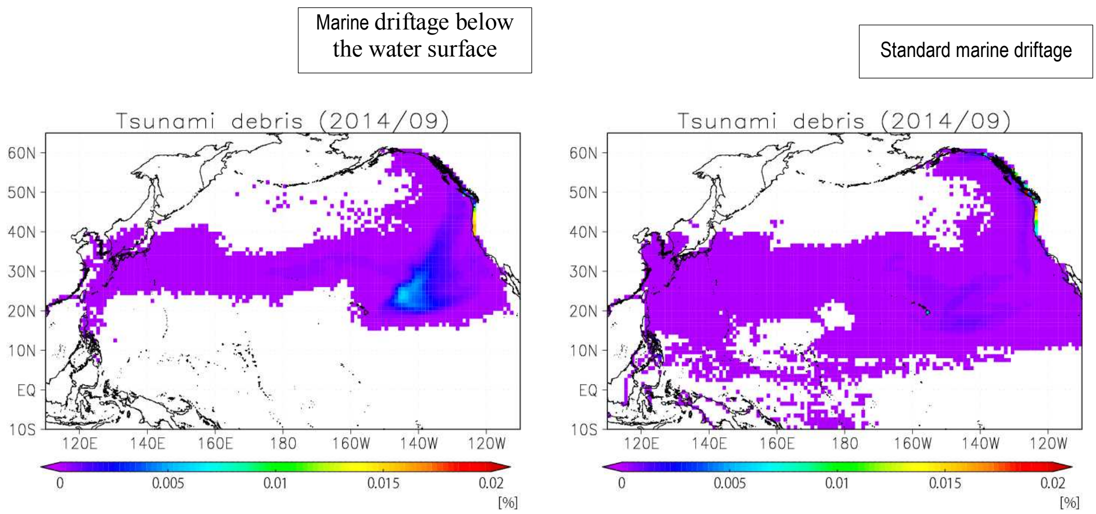

Figure 33 (Same as Figure 28) Distributions on September 15, 2014.

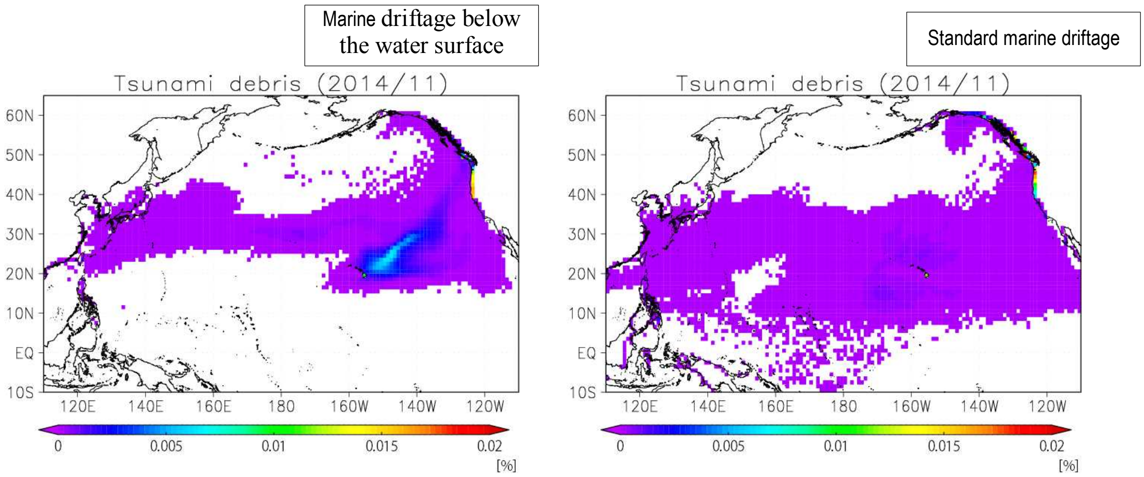

Figure 34 (Same as Figure 28) Distributions on November 15, 2014.

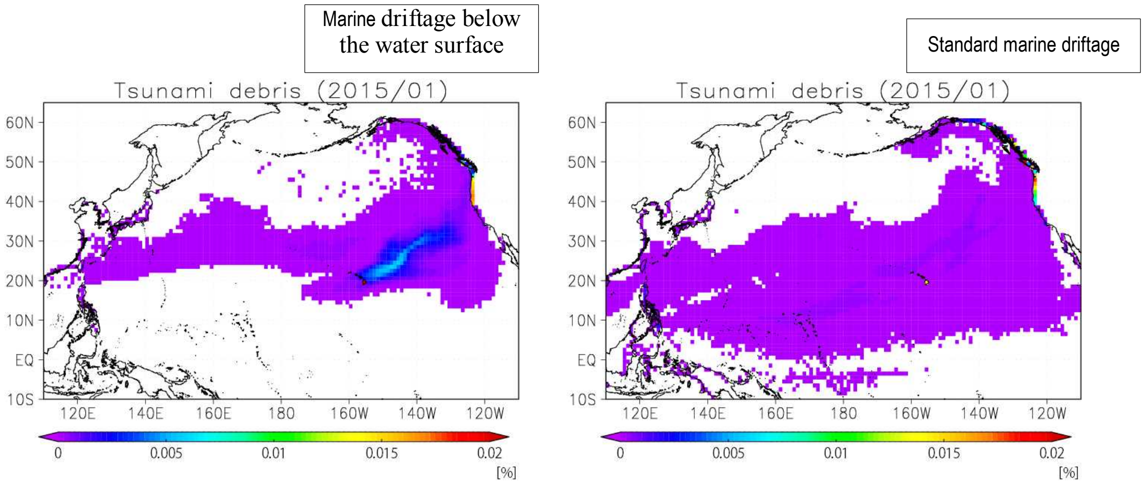

Figure 35 (Same as Figure 28) Distributions on January 15, 2015.

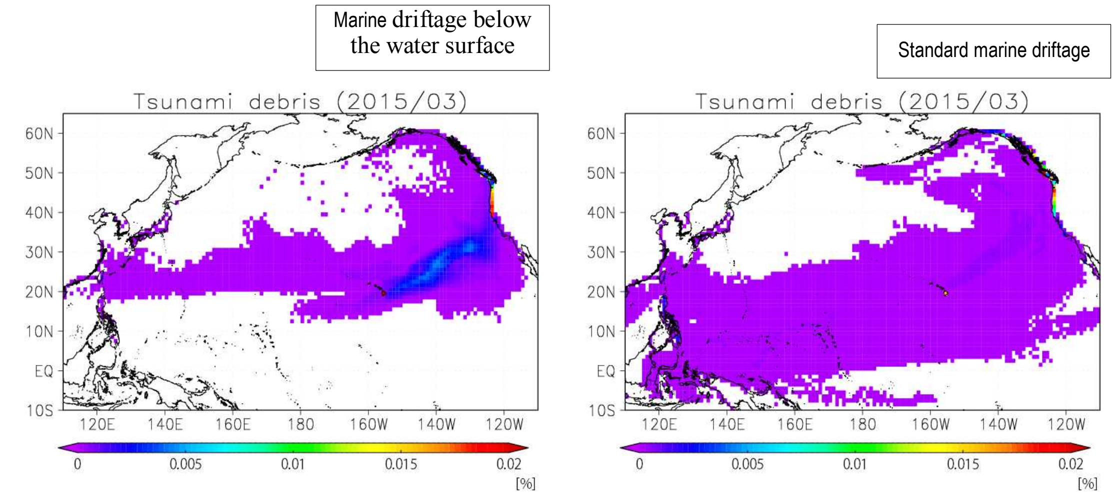

Figure 36 (Same as Figure 28) Distributions on March 15, 2015.

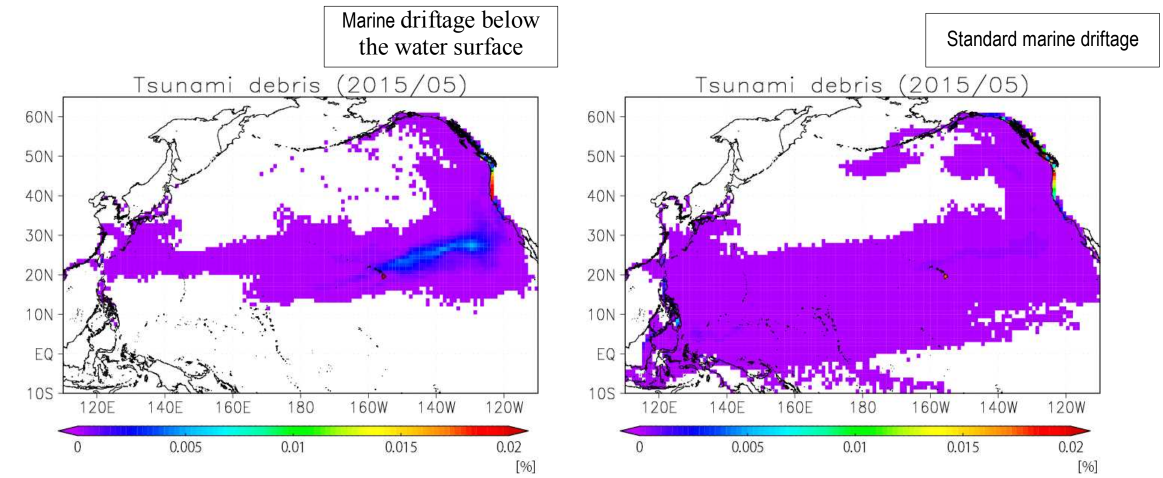

Figure 37 (Same as Figure 28) Distributions on May 15, 2015.

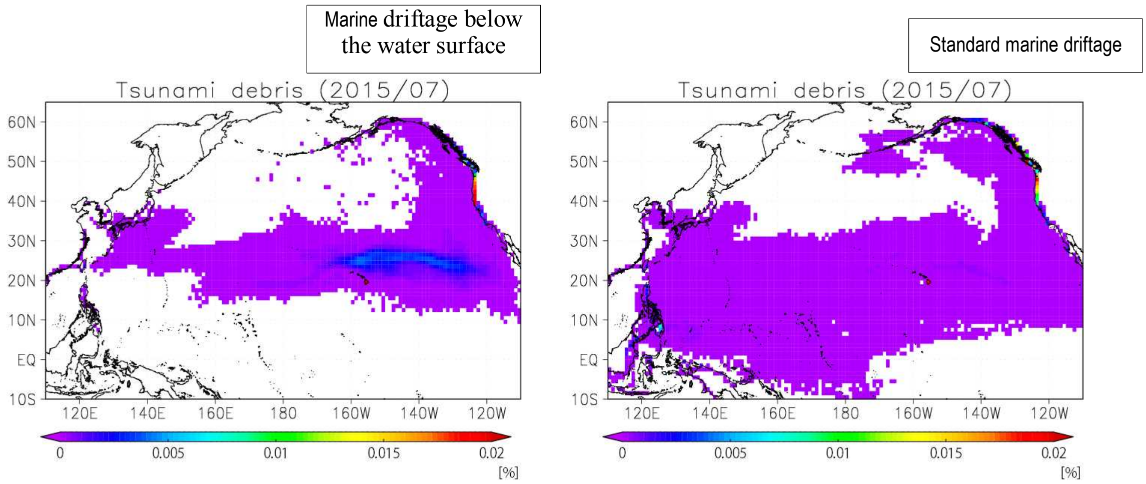

Figure 38 (Same as Figure 28) Distributions on July 15, 2015.

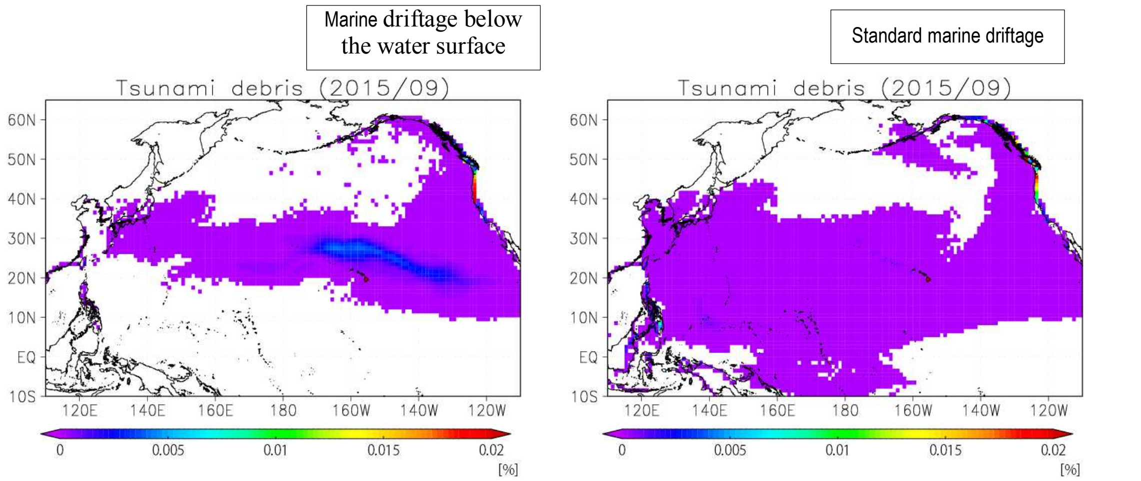

Figure 39 (Same as Figure 28) Distributions on September 15, 2015.

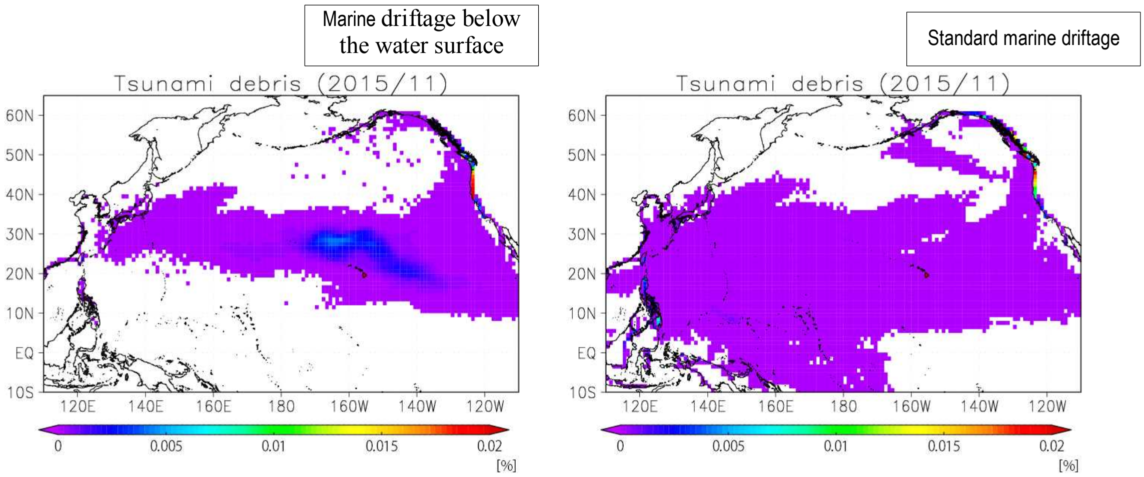

Figure 40 (Same as Figure 28) Distributions on November 15, 2015.

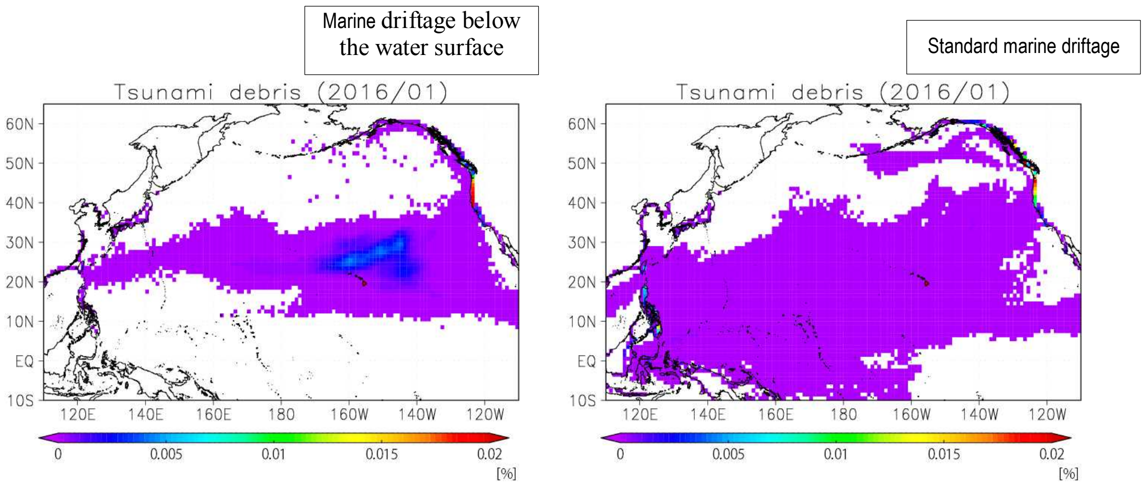

Figure 41 (Same as Figure 28) Distributions on January 15, 2016.

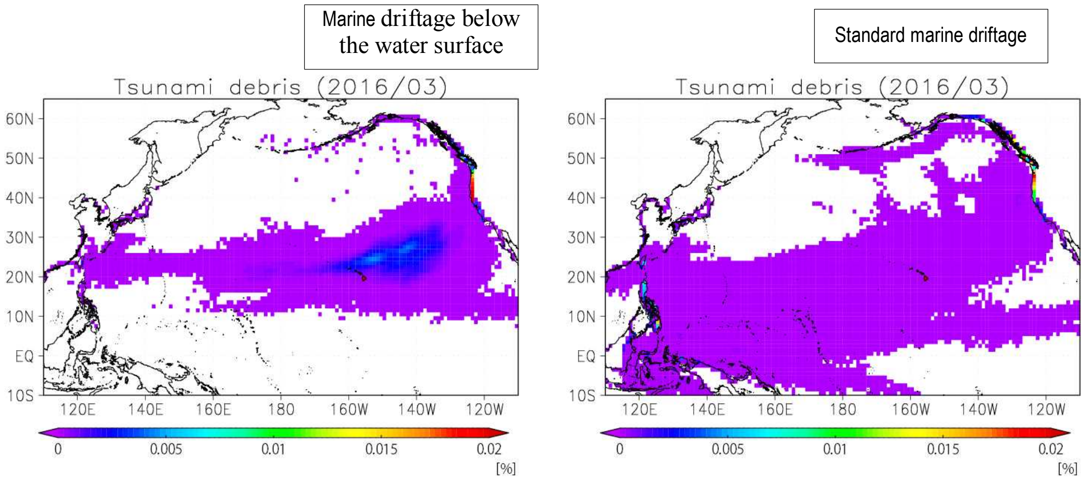

Figure 42 (Same as Figure 28) Distributions on March 15, 2016.

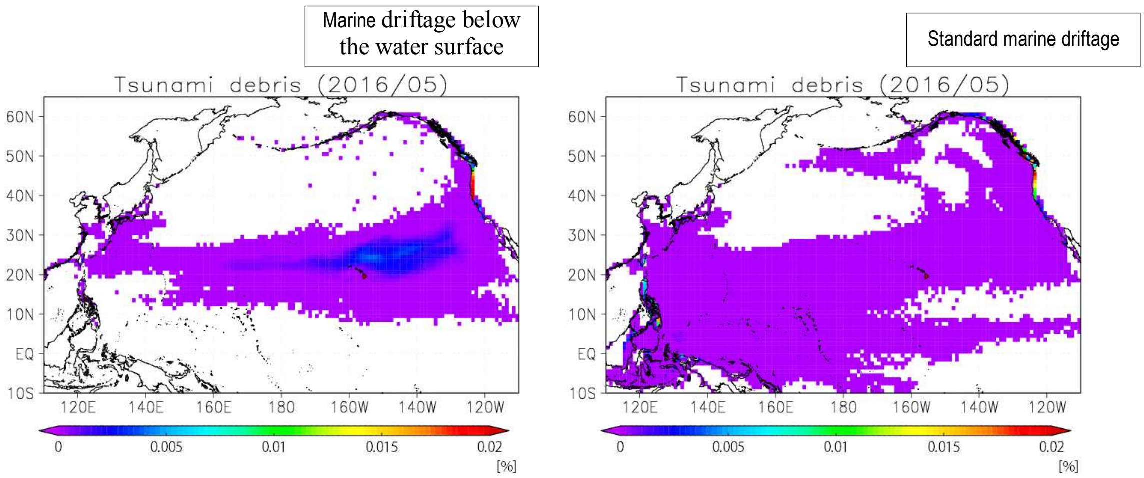

Figure 43 (Same as Figure 28) Distributions on May 15, 2016.

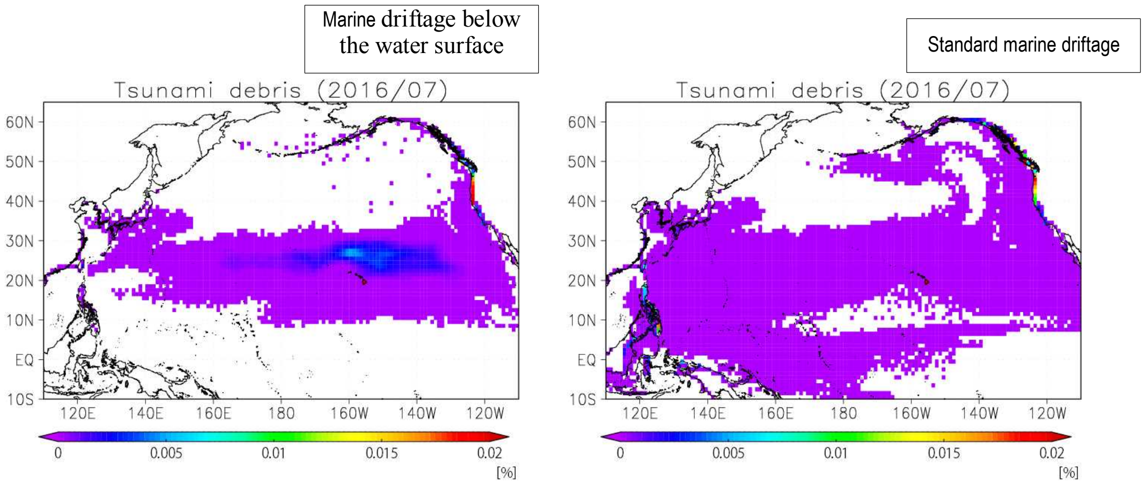

Figure 44 (Same as Figure 28) Distributions on July 15, 2016.

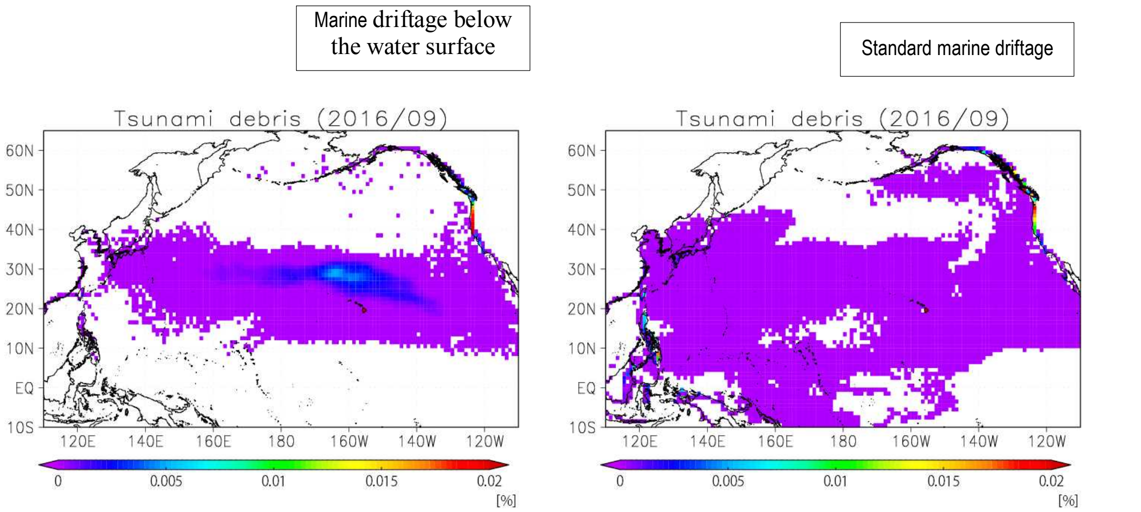

Figure 45 (Same as Figure 28) Distributions on September 15, 2016.

3.5 Summary of Simulation

Abundant marine driftage resulting from the Great East Japan Earthquake was simulated using ocean-current and ocean-wind data from March 2011 to September 2013 in addition to the forecast ocean-current and ocean-wind data from October 2013 to September 2016 in this program. An ensemble forecast calculation was also conducted to forecast highly accurate distributions of marine driftage in the future.

The results indicate that the marine driftage below the water surface is estimated to arrive in bulk at the west coast of the North American continent beginning in 2014, and the possibility of the repeated arrival of the majority of marine driftage, or standard marine driftage, is also suggested. The marine driftage off the west coast of North America is forecast to move to the north and south respectively due to the Aleutian low, which develops in the North Pacific Ocean in winter, and the North Pacific high, which develops in summer. This marine driftage would then be driven in a southwesterly direction and be distributed in a zonal shape near the Philippine islands by the North Equatorial Current and trade winds. Moreover, it is suggested that the marine driftage below the water surface will tend to accumulate in the sea areas north of the Hawaiian Islands.

4 Experts' Meeting and General Symposium

An experts' meeting was held in the Okinawa Prefecture on October 24 and 25, 2013, in which experts on marine driftage were invited to exchange information on the simulation conducted in this program and international approaches to marine driftage simulation. A symposium for the general audience was also held during this period.

This meeting was held at the Global Oceanographic Data Center (GODAC) of JAMSTEC in Nago city on October 24. A summary of the simulation results in this program was initially presented first, whereupon the topic was discussed, and the invited experts presented their research and work. The guest speakers and their presentations are listed below:

● Dr. Jon Rees (Chief, Centre for Environment, Fisheries and Aquaculture Science)

Introduction of the monitoring and research of marine driftage in the U.K.

Emergency response to the marine driftage caused by maritime accidents, and coastal monitoring of marine driftage

● Prof. Nikolai Maximenko (International Pacific Research Center, University of Hawaii)

Simulation research of marine driftage at the University of Hawaii

● Prof. John P. Matthews (Kyoto University)

Monitoring of marine driftage using satellite remote sensing images

Figure 46 Experts' meeting at the Global Oceanographic Data Center (GODAC) on October 24, 2013, in Nago, Okinawa Prefecture.

A symposium for the general audience was held at the Okinawa Institute of Science and Technology (OIST) Graduate University in Onna-Son on October 25.
The symposium programs are shown below:

Opening address: Masaaki Kobayashi (Director-general of the Water and Atmosphere Environment Agency, Ministry of the Environment)
Greeting: Nancy Wallace (Marine Debris Division, Chief, U.S. NOAA) (Cancelled)
Summary and results of the Japan–U.S. joint drift simulation: Toshiyuki Awaji (Executive board member and vice president, Kyoto University)
Introduction of drifting forecast simulation in Japan
1) Air–sea variation ensemble forecast experiment
○ Norihisa Usui (Senior researcher of the Meteorological Research Institute, Japan Meteorological Agency)
Yoichi Ishikawa (group leader of JAMSTEC)
2) Marine driftage behavior forecast
○ Hideyuki Kawamura (assistant research manager, JAEA)
Takuya Kobayashi (assistant research manager, JAEA)
(Break)
Marine driftage forecast simulation in the U.S. by National Ocean and Atmosphere Administration (NOAA) [video presentation scheduled] (cancelled)
Amy MacFadyen, Glen Watabayashi (NOAA, Seattle)
Satellite monitoring of marine driftage
John Phillip Matthews (Professor, Kyoto University)
Emergency response and coastal monitoring in U.K.
Jon Rees (Chief, Centre for Environment, Fisheries and Aquaculture Science)
Visual information from boats and ships
Shigeru Fujieda (Professor, Kagoshima University)
Marine debris simulation research in University of Hawaii
Nikolai Maximenko (University of Hawaii)
Comments from floor
Closing address: Shiro Imawaki (Chief of Data Research Center for Marine-Earth Sciences, JAMSTEC)

Nearly 100 people participated in the symposium for presentations, which included the simulation results in this program, remote sensing images from satellites, reports of marine driftage monitoring from ships and boats, and challenges faced by foreign countries.
A researcher for the National Ocean and Atmosphere Administration (NOAA) in the United States, who is responsible for monitoring marine driftage, was invited but could not travel to Japan due to the closure of

U.S. government agencies. The previous e-mail correspondence was introduced in lieu of the presentation.

Figure 47 Symposium for the general audience held at Okinawa Institute of Science and Technology Graduate University in Onna-Son on October 25, 2013.

5 Summary of the work

The marine driftage resulting from the Great East Japan Earthquake was subject to numerical simulation for three years beginning in 2011 to estimate and predict its distributions. Because the program started soon after the earthquake, simulation methods were developed and implemented, and goals were set for obtaining estimations as rapidly as possible in the initial fiscal year. Until observation data on ocean-wind and surface-current speed could been obtained, which were required for the drifting simulation, data from the MOVE-WNP ocean-data assimilation system and JCDAS analysis field for ocean wind were used, while K7 data was used for long-term prediction. Based on these types of data, the SEA-GEARN Ocean Dispersion Model was modified for marine driftage simulation. The volume proportions for the parts above and below the water surface were classified into four types, 4:1, 2:1, 1:1, and completely submerged, to simulate the behavior of marine driftage. The drifting parameters offered by the Japan Coast Guard were used. According to these parameters, lumber, which accounted for the majority of driftage in the sea, was classified into the standard marine driftage (1:1) category.

Visual data and driftage reports were used for comparisons to evaluate the reliability of the simulation in the FY 2012 Program, and studies were also conducted in some cases to improve the simulation accuracy.

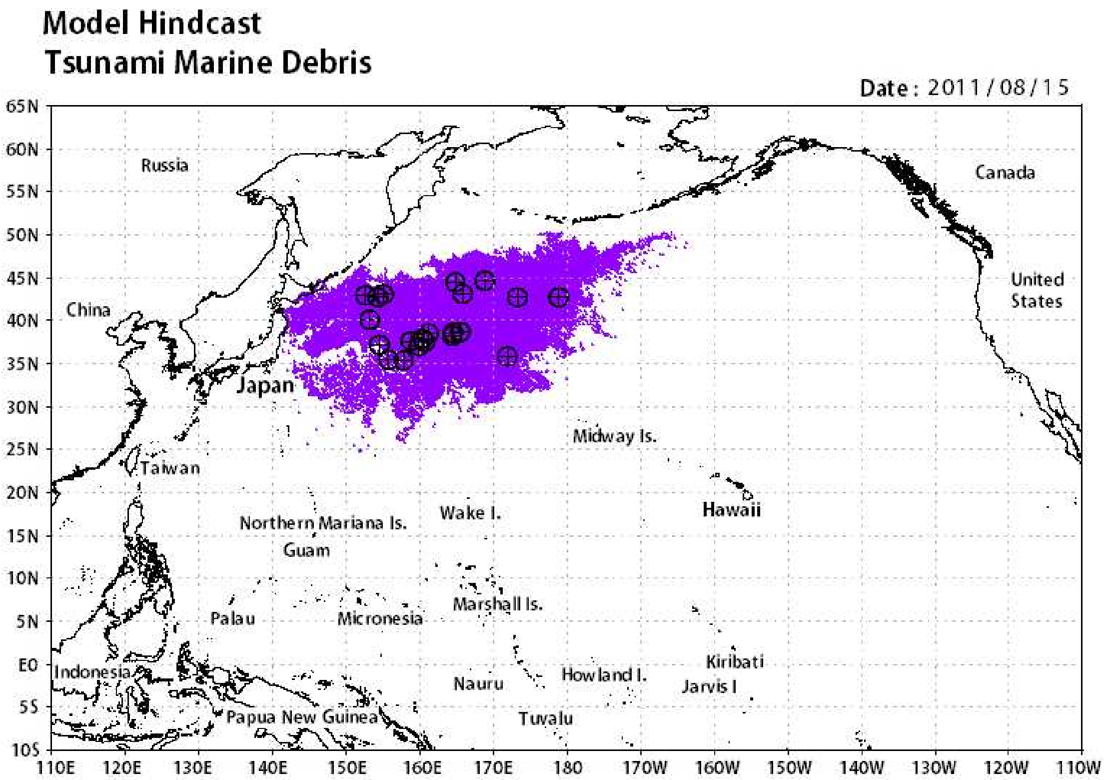

Figure 49 Simulation results in August 2011 and visual information.

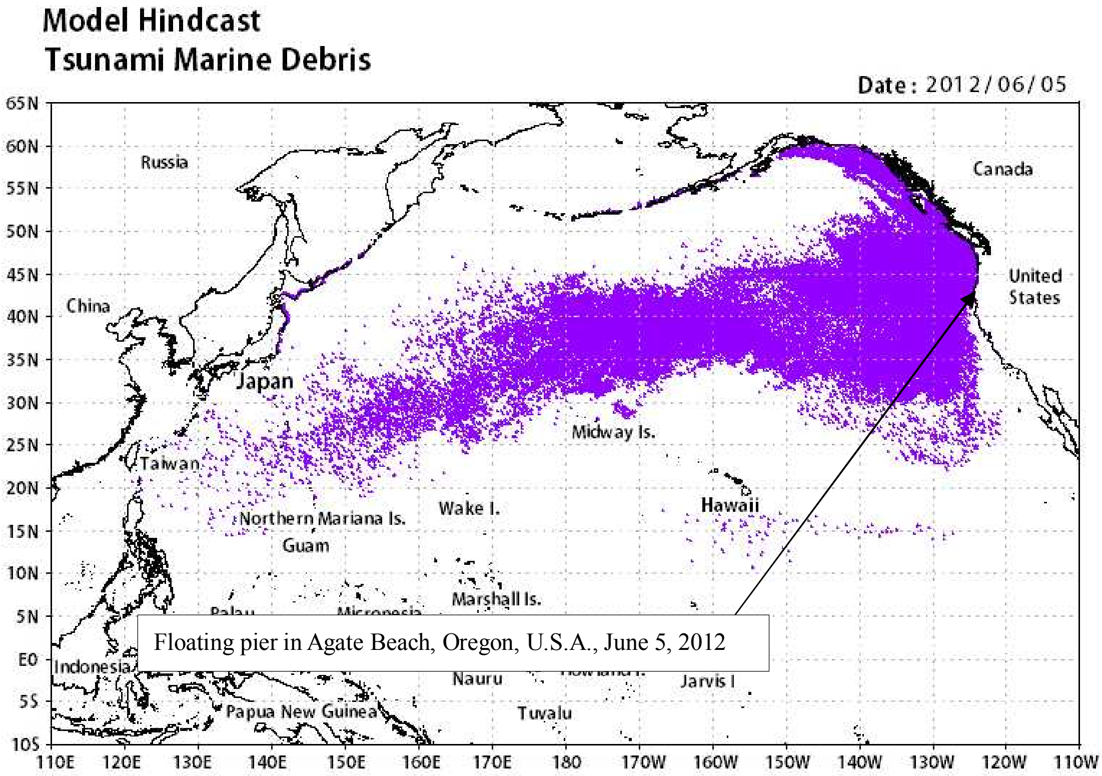

Figure 50 Simulation results in June 2012 and arrival reports.

In 2012 in particular, many reports on the arrival of earthquake-induced marine driftage at the west coast of North America were submitted, the locations and times of which were roughly consistent with the simulation in this program. Although most marine driftage was classified as nearly all above the water surface, the estimation of the Ministry of the Environment stated that most of the marine driftage was below the water surface. Therefore, more detailed conditions must be examined when simulating this type of marine driftage. The initial flow distribution, handling of arrived marine driftage, long-term degradation of lumber, and uncertainties of ocean-wind and ocean-current prediction were discussed here and are subject to case study. The ocean wind and current obtained from the ensemble calculation were used and simulated to evaluate the uncertainties of ocean-wind and ocean-current prediction, which exerted the largest influence in the simulation (Figure 27). The result and simulation using reanalyzed data were compared to evaluate the influence of uncertainties of ocean wind and current. When these parameters varied, although significant variation was observed in ensemble members, some presented similar results to that of the simulation that used reanalyzed data: such results were obtained by averaging the ensemble. The reliability was significantly improved compared with individual simulations.

Based on these results, marine driftage showing a 1:1 ratio of volumes above and below the water surface and all below the water surface was simulated in this fiscal year. Most of this driftage is lumber currently in the Pacific Ocean. The calculation results for analysis and prediction using the latest observation data were used for ocean current and ocean wind. Chapter 3 of this report summarizes the results, whereas Chapter 4 discussed an experts meeting that included guests from across the world and a symposium for the general audience held to report a summary of the three-year program.

The research results obtained in this program were distributed to related organizations in Japan and other countries and are believed to have contributed significantly to the research of marine driftage behavior. Information must be shared among related organizations to solve problems related to marine driftage caused by the Great East Japan Earthquake. The simulation of drifting marine driftage in this program assumes relatively longer timescales and a larger spatial scale. To clarify the detailed behavior of marine driftage along the coast, a simulation containing higher resolution than the temporal and spatial resolution used in this program will be required, and enhanced simulation technology is desired for studying marine driftage in the future.

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リサイクル適正の表示：印刷用の紙にリサイクルできます。

この印刷物はグリーン購入法に基づく基本方針における「印刷」に係る判断の基準にしたがい、印刷用の紙へのリサイクルに適した材料[A ランク]のみを用いて作成しています。