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- Volume 2: Radiocarbon and Oceanographic Properties -

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Establishment of Database for Japan Sea Parameters on Marine Environment and Radioactivity (JASPER) - Volume 2: Radiocarbon and Oceanographic Properties -

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The database for the Japan Sea Parameters on Marine Environment and Radionuclides (JASPER) has been established by the Japan Atomic Energy Agency as a product of the Japan Sea Expeditions. By the previous volume of the database, data for representative anthropogenic radionuclides (strontium-90, cesium-137, and plutonium-239, 240) were opened to public. And now, data for radiocarbon and fundamental oceanographic properties (salinity, temperature, dissolved oxygen) including nutrients (silicate, phosphate, nitrate and nitrite) are released as the second volume of the database. At the beginning of this report (chapter 1), backgrounds, objectives and brief overview of this report are given as an introduction. Then, specifications of this database and methodology in obtaining the concentration data are described in chapter 2. The data stored in the database are presented in tabular and figure forms in chapter 3. Finally, chapter 4 is assigned concluding remarks. In the second version of database, 20,292 data records are stored in the database including 2,695 data for temperature, 2,883 data for salinity, 2,109 data for dissolved oxygen, 11,051 data for the nutrients, and 1,660 data for radiocarbon. The database will be a strong tool for the continuous monitoring for contamination by anthropogenic radionuclides, studies on biogeochemical cycle, and development/validation of models for numerical simulations in the sea.

Keywords: Japan Sea Expedition, Database, Radiocarbon, Temperature, Salinity, Dissolved Oxygen, Nutrients, Seawater.

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データベース
"Japan Sea parameters on marine environment and Radioactivity (JASPER)" の構築
- 第 2 巻: 放射性炭素および海洋学的指標成分-

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原子力機構が実施した日本海海洋調査の最終成果物のひとつとして、日本海の海洋環境パラメータと放射性核種に関するデータベース (JASPER) が構築された。本データベースの第 1 巻では、代表的な人工放射性核種として、ストロンチウム-90、セシウム-137 およびプルトニウム-239, 240 の観測データが公開された。そして今、その第 2 巻として、放射性炭素データと、栄養塩（ケイ酸、リン酸、硝酸及び亜硝酸）を含む海洋学的指標（塩分、水温、溶存酸素）のデータが公開される。本報告書の冒頭（1 章）には、序論として、背景、目的、本報告書の概要が記されている。第 2 章には、本データベースの仕様及び収録された核種濃度データを取得した際の手法が記述されている。また、第 3 章には、収録されているデータの内容が表形式及び図によって示されている。そして、第 4 章は、結言に与えられている。この第 2 巻には、現時点で 20,398 データレコードの登録があり、その内訳は、水温が 2,695 データ、塩分が 2,883 データ、溶存酸素が 2,109 データ、栄養塩が 11,051 データ、放射性炭素が 1,660 データである。このデータベースは、人工放射性核種による日本海の汚染状況の継続的な監視、日本海内の生物地球化学的循環、数値シミュレーションモデルの開発検証の各分野において強力なツールとなることが期待される。

本報告書の一部は、文部科学省の受託調査「放射性廃棄物の投棄海域等における海洋環境放射能の影響に関する調査」及び「日本海における放射性物質の循環と蓄積に関する調査」の成果である。
本研究の一部は日本原子力研究開発機構と（独）水産総合研究センター中央水産研究所、（独）国立環境研究所、九州大学応用力学研究所の各機関との共同研究に基づいて実施したものである。
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1. Introduction

The database for Japan Sea Parameters on Marine Environment and Radioactivity (JASPER) has been developed by Japan Atomic Energy Agency (JAEA), and now the part of parameters on fundamental characteristics of seawater and isotopic ratio of radiocarbon is opened to the public.

1.1 Background

Former Japan Atomic Energy Research Institute (JAERI) had conducted a multi-year research project in the Japan Sea named Japan Sea expeditions (phase 1; 1997-2002). During the phase 1 expeditions, 12 research cruises were carried out in the Japanese EEZ (Exclusive Economic Zone), and 4 cruises were carried out in the Russian EEZ. The cruises in the Russian EEZ were conducted under the framework of the ISTC partner project. Since 2004, JAERI/JAEA proceeded 9 research cruises in the Japanese EEZ under the joint researches with domestic research institutions (phase 2). In the phase 2 expeditions, several regions of where little data have been obtained during the phase 1 were observed. Consequently, we visited 161 stations during a series of expeditions (Figure 1).

Two main motives had combined to make us to conduct the project. One of the motives was to monitor the impacts of radioactive wastes dumped in the Japan Sea. Understanding the level of anthropogenic radionuclides in the Japan Sea is important for Far Eastern Countries because there are many potential sources of the radionuclide releases to the Japan Sea, such as a variety of nuclear facilities in the regions surrounding the sea. The other was to investigate the processes of water circulation and the migration behavior of radionuclides in the Japan Sea. The Japan Sea is known as the largest marginal sea in the world that has bowl-like topography and open ocean-like seawater circulations. From these characteristics, many oceanographers regard the sea as a "miniature" of the ocean. The Japan Sea, therefore, would be the most suitable field for the better understanding of general transport processes of radionuclides in the marine environment.

At the present, more than 3,000 seawater samples have been collected and a lot of parameters including radionuclides data have been obtained. The parameters classified as follows:

- Physical properties (temperature and salinity),
- Radionuclides (^{3}H, ^{14}C, ^{90}Sr, ^{129}I, ^{137}Cs, ^{226}Ra, Pu),
- Stable isotopes (^{13}C and ^{18}O),
- Nutrients (silicate, nitrate, nitrite and phosphate),
- Organic carbon,
- Gaseous substances (oxygen, total inorganic carbon, and CFCs).

More detailed information for the backgrounds, contents and results of the Japan Sea expeditions can be referred to the summary reports by Togawa et al. (2006; 2007)[1), 2)].

1.2 Objectives to construct the database

One of the main objectives to construct this database is to support to achieve above-mentioned motives as well as to prevent a scatter and loss of the data in passing time. For the former motive, that is, for the monitoring. It is obvious that the data for anthropogenic radionuclides themselves become the main parameter. At the same time, other elements/isotopes and oceanographic parameters stored in this database might help to speculate the source and migration of anthropogenic radionuclides. On the other hand, for the latter motives, some of the parameters can be used as transient tracers, since their fates in marine environment are relatively well elucidated. Complementary use of other chemical and physical parameters may contribute to improve the utilities of data of anthropogenic radionuclides in multi-tracer analysis. As just described, to make a database of systematically collected data in the Japan Sea has a great merit for both motives mentioned above.

Additionally, we thought that the database has two more important roles. The distributions of anthropogenic radionuclides and/or other trace elements extracted from the database can be used for validation of numerical models, which are used in environmental simulation. Furthermore, we expect that this consolidated database provide information about radionuclides and biogeochemical structures in the Japan Sea to the public.

1.3 Information about the 2nd volume of JASPER database

As mentioned above, the data obtained through the Japan Sea Expedition cover a lot of parameters, and some of the parameters are now under measurement. Considering this situation, we decided to publish the data as a partwork. In the previous volume of this database[3)], 622 data on the representative anthropogenic radionuclides (^{90}Sr, ^{137}Cs and ^{239,240}Pu) in seawater and seabed sediments were stored. And now, the second volume is assigned to describe the parts of radiocarbon and oceanographic properties. The former part means isotopic ratio of ^{14}C/^{12}C in dissolved inorganic carbon, and the latter part includes salinity, temperature, concentration of oxygen and nutrients. Both parts play an important role in understanding the structure and seawater circulation of the sea.

At the opening of section 2, the structures of record for the data in the database are introduced, and information about data quality is indicated. The information about sampling site and methods are described in section 2.2. Then, the analytical methods are given in section 2.3.

The section 3 is spent to describe the data itself with tabular form and figure form. And, concluding remarks are given in section 4. The remaining data, such as ^{3}H and ^{129}I, are planned to be included in other volumes, which will be published in the future.

2. Methods and Materials

2.1 Information about record format and quality control of the database

The definition of terms used in the database is given in Tables 1-1 and 1-2. In this database, the data obtained at the same sampling time are recorded all together including support data. So, the package of data is referred to as “data record” in this report. The data record is started with the information for origin of the data and ended with the termination code (“z” is used for the code). The anterior half of the data record, column number 1 - 29 of data record, contains the support data (support data part) that are used to identify the position and time for the observation/sampling in order to make sense of distribution of main data recoded in successive part. The last half of the data record (column number 30 or later) is assigned to store main data (main data part). This part consists of data blocks from 1 to more than ten depending on the situation of sampling. The components of the data block are “type of element”, “element name”, “measured value”, “error of the measurement”, “unit of the value” and “flag for quality control”. The cord “-99” recorded in the “origin” column indicates the termination of the database.

In this database, flags for quality control are given to all the measured data, not only for the main data but also for the support data (except for date and time data). The quality of data is classified into 3 ranks with titles of “good”, “suspicious” and “bad”. The rank of “good” is given to the data that measured by reliable equipment with good quality. The data indirectly measured or with suspicious (i.e., unreasonable data that can not be rejected statistically) quality are classified into the “suspicious” rank. The “bad” rank includes the case that the data is not obtained or the data has invalid (i.e., statistically rejectable) value.

2.2 Sampling sites and methods

In the Japan Sea Expedition, the samplings for anthropogenic radionuclides were performed at 161 sites through 22 cruises including the sites for re-visit observation. Within them, 18 cruises were carried out in the Japanese EEZ by us (former JAERI) and 4 cruises were done in the Russian EEZ under the framework of ISTC partner project. These cruises were carried out under cooperation with 9 research vessels, R/V *Professor Khoromov*, (Far Eastern Regional Hydrometeorological Research Institute, Russia), R/V *Wakashio Maru* (Nippon Salvage, Co), T/S *Hokusei Maru*, T/S *Oshoro Maru* (Hokkaido Univ.), R/V *Kaiko Maru No.12* (Offshore Operation, Co.), *Kaiyo Maru No.7* (Nippon Kaiyo, Co.), R/V *Hakuho Maru* (Univ. of Tokyo, at 2002), R/V Soyo Maru (National Research Institute of Fisheries Science), and R/V *Koshiji Maru* (Niigata Pref.). The details about sampling stations were summarized in Table 2.

Seawater samples were collected using a MBS (Multi Bottle Sampler) system with multiple Niskin Bottles. This system is connected with a CTD (Conductivity-Temperature-Depth profiler) system and can collect seawater sample at specified depths automatically. Seawater samples in the sampling bottles are transferred to a cup/container on board (i.e., subsampling) and stored until the measurement.

2.3 Analytical methods

Salinity data in this report is obtained by two methods, one is *In-situ* measurement using CTD and another is measurement using a Salinometer. In the latter method, conductivity of seawater sample was measured with a Guildline Salinometer, model 8400B[4)]. For temperature data, *In-situ* temperature data obtained by CTD observation were stored in this database.

Dissolved oxygen was determined by the high precise Winkler’s titration method[4)], and the typical accuracy was less than 0.3 % as a 1-sigma. Nutrients (silicate, phosphate, nitrate and nitrite) were measured by the spectrophotometrical method with continuous flow automated analysis[4)], and the typical accuracy was less than 1 % as a 1-sigma. By this method, nitrate data were obtained by subtracting nitrite concentration from the total nitrogen (nitrate and nitrite) concentration. Therefore, data of nitrate, nitrite and total nitrogen are stored in the database independently.

With regard to the analysis of radiocarbon, seawater samples were stored in a glass bottles with high-quality stoppers after sterilized with 100 µl of saturated mercury chloride solution on board. The dissolved inorganic carbon in seawater samples was evolved as CO_2 gas by adding 4 ml of 100 % H_3PO_4 and collected cryogenically by purging with pure N_2 gas in the vacuum system[5)]. The CO_2-C was reduced to graphite with pure H_2 gas over an iron catalyst at 650 °C. The graphite was pressed into targets for AMS-C measurements. The $^{14}C/^{12}C$ ratios of the sample graphite were measured by a Tandetron AMS (HVEE, model 4130-AMS) at JAEA-AMS-MUTSU against with a NIST oxalic acid ^{14}C standard (HoxII, SRM-4990C). In this database, the $^{14}C/^{12}C$ ratios are expressed by ÷^{14}C, which is calculated by equations in Stuiver and Polach (1977)[6)]. The precision of our AMS measurement is typically less than ±5 ‰ as a 1-sigma of the counting statistics. The background level is estimated to be 2 % of modern carbon. The ι^{13}C (vs PDB) values of samples and the standard are measured for sub-samples of the CO_2 gas separated before the graphite production, by a triple collector mass spectrometer (Finnigan, DELTA-plus) with a precision of ± 0.05‰. The ^{13}C data are not stored in the database.

3. Data of radiocarbon and oceanographic properties

In the second volume of the database, data records for 3,062 seawater samples are accumulated. In order to show the overview of the data, statistical information for the data in the database is given in Table 3. In addition, depth-profiles of temperature (potential temperature), salinity, silicate, oxygen, phosphate, total nitrogen (nitrate and nitrite) and ÷^{14}C are shown in Figures 2, 3, 4, 5, 6, 7 and 8, respectively. In order to show regional variations, each figure consists of four areal groups as follows;

Area I: Western region (< 136°E) of the Japan Basin,

Area II: Eastern region (> 136°E) of the Japan Basin and northeastern shelf,

Area III: Yamato Basin and Yamato Rise,

Area IV: Tsushima Basin and southwestern shelf.

At the present, totally 2,695 valid data (i.e., data excluding error code) of temperature data are stored in the database. All the valid data were evaluated as “good” quality. The temperature ranged between 0.051 and 32.872 °C. As mentioned above, *In-situ* temperature data are stored in the database. In order to cancel the bias of the pressure, potential temperature is calculated from the *In-situ* temperature, salinity and pressure data[7)]. The depth-profiles of potential temperature are shown in Figure 2. Temperature in the surface water varied regionally/seasonally, and was higher in the southern regions (i.e., area III and IV). In these regions, seawater with high temperature covered the 100-200 m surface layers. This indicated the inflow of the Tsushima Warm Current (TWC) from the East China Sea. Potential temperature in the deep water (> 1,500 m) was 0.09±0.02 °C. This water mass with low temperature is known as the Japan Sea Proper Water (JSPW)[8)].

Total number of valid data for salinity stored in the database is 2,883. Within them, 2,881 and 2 data were categorized in “good” and “suspicious” criteria, respectively. We considered that the suspicious data were due to instrumental problem during the measurement. Vertical profiles of salinity in areas I-IV are shown in Figure 3. Salinity in the surface water ranged between 32.6 and 35.1. Especially in the southern regions (area III and IV), higher salinity exceeding 34.5 was observed and it also indicated the signature of TWC water. In the deepwater (> 1,500 m), salinity ranged within 34.068±0.005 and was typical value of JSPW reported previously[8)].

Totally 2,109 of valid data were obtained for dissolved oxygen. Thirteen data (0.6% of valid data) were permitted in “suspicious” category, and were inferred due to mixing of plural water masses during the sample collection or accidental contamination during the sampling. However, we did not reject them because the cause was not determined completely. Data of dissolved oxygen ranged between 3.538-8.312 ml/l and the vertical change is shown in Figure 4. It is known that the Japan Sea has higher concentration of oxygen because of its faster seawater circulation compared with the open oceans[9)]. Especially in the northern regions (Area I and II), higher concentrations of oxygen were observed in the surface and intermediate layers (0-1000 m). This was due to the higher solubility of oxygen in the lower temperature and effective transport of surface waters to the interior of the sea[10)]. In the northern regions, it is also remarkable that high oxygen concentrations were obtained at the bottom of several stations. These results were mainly observed in 2001, and were inferred due to the transport of surface waters to the bottom layer (i.e., formation of the bottom water)[11), 12)]. It was considered that the formation of the bottom water occurs continuously but has been stagnant during the last four decades[13)]. However, the results in Figures 4 (I) and (II) indicated that the formation occurs sporadically even in the recent years.

With regard to silicate (expressed as “Si” in Table 3), 2,361 valid data are stored in the database. The number of “good” data is 2,332 (98.8% of the valid data), “suspicious” one is 12 (0.5%), and “bad” one excepting error code is 17 (0.7%). Silicate concentration in seawater ranged between 0.0 and 97.3. The concentration was about zero at the surface and increased with depth (Figure 5). In the marine environment, nutrients including silicate are supplied to the surface from the river input and/or upwelling of the deep water. Nutrients in the surface waters is utilized by phytoplankton and transported to the deep water as a part of sinking particles. Concentration of nutrients in the deep water increases according to the decomposition of sinking particles. Sediment trap experiments in the Japan Sea revealed that biogenic opal (amorphous silicate) is dominant component of sinking particles, and the sinking flux is higher than the other oceans[14), 15)]. However, concentration of silicate in JSPW is lower than oceans (e.g., >100 μmol/l at the North Pacific). This result indicates that the Japan Sea has the shorter timescale of the nutrient cycle compared with the open oceans. The highest concentration of silicate was observed in the southern margin (Area IV). In the deep part of southern Japan Sea, it is suggested that significant amount of terrestrial materials were supplied from the East China Sea[16), 17)]. The high concentrations of silicate observed in the Area IV also would indicate the supply of terrestrial silicates from the Asian Continent. It is suggested that the latitudinal difference in transport processes of terrestrial materials also affect the distribution of physical properties[18)] and micronutrients[19)].

The number of valid phosphate (“P” in Table 3) data in the database is 2,340 including 2,316 of “good” data (99.0%) and 24 of “bad” data (1.0%). The “bad” data were rejected because sufficient reproducibility was not obtained. Similarly to vertical distribution of silicate, that of phosphate is about zero at the surface and increase with depth (Figure 6), and the increasing rate was higher than that of silicate in the subsurface layer. The difference is quite reasonable because phosphate and nitrogen are contained in organic component while silicate composes insoluble shell or clay minerals. As the labile organic matters decompose at the shallower waters, concentration of their substances increases at the shallower layer. Ito et al. (2003; 2005)[20, 21] pointed out maximum concentration of plutonium, which is known as a particulate-reactive radionuclide, in the intermediate layers of the Japan Sea (c.a. 500-1000 m depths). The maximum is supposed to indicate dissolution/decomposition of particles in the water column. Considering the depth range, the maximum of plutonium would be controlled by dissolution of organic particles rather than that of shell of marine biota.

There are three types of data for nitrogen oxides; nitrate, nitrite and the sum of nitrate and nitrite ("NO_3", "NO_2" and "NO_x" in Table 3, respectively). As a representative data, vertical distributions of nitrogen oxides (nitrate + nitrite) are illustrated in Figure 7. The number of valid data for nitrate, nitrite, and the sum of the oxides was 2,006, 2,007 and 2,337, respectively. Within them, the number of "good" data was 1,685 (84.0% of valid data), 1,982 (98.8%), and 2,025 (86.6%), respectively.

As mentioned in subsection 2.3, data of isotopic ratio of radiocarbon is expressed in ÷^{14}C value. This is the per mil deviation of the isotopic ratio of radiocarbon (half life = 5730 yrs) from a standard and is normalized to a ι^{13}C of –25‰[6]. Since ÷^{14}C value of atmospheric CO_2 at 1950 is defined as zero, a positive (+) ÷^{14}C value in seawater indicates that the water contains artificial radiocarbon. If a seawater sample has negative (-) ÷^{14}C value, on the other hand, the deficit indicates the degree of radioactive decay that correlates with "apparent age" of the seawater. Even though it is difficult to estimate the "actual age" of seawater because ÷^{14}C values are controlled by the both effects, the value is quite useful indicator to understand the seawater movement/circulation. In the database, 1,660 of valid ÷^{14}C data including 1,572 (94.7%) of "good", 84 (5.1%) of "suspicious", and 4 "bad" (0.2%) data were stored. We considered that the suspicious data may be caused by addition of atmospheric carbon into samples during the sampling or storage procedures.

÷^{14}C in the surface waters (0-100 m) ranged between 21.7 and 94.0‰ (Figure 8). The values in the southern region (70.6±12.5‰ in Area IV) were higher than that in the northern region (55.2±8.5 in Area II). This result may indicate that the southern Japan Sea is affected by the TWC water that originates from subtropical Pacific and has high radiocarbon content. In the surface and sub-surface layers (0-500m), the "shape" of vertical change in ÷^{14}C was different between the northern (Area I and II) and southern (III and IV) regions. While the depth-profiles in the northern regions seemed to concave, those in the southern regions were convex. These differences might be caused by vertical mixing of surface waters in the northern regions[10, 22] and inflow of TWC water to the surface of southern regions. ÷^{14}C value at 1 km depth was -9.7±11.1‰ in the Area I, -21.8±12.0‰ in the Area II, -20.6±14.8‰ in the Area III, and -22.6±5.4 in the Area IV, respectively. The higher ÷^{14}C values in the northwestern regions (Area I) might indicate the transport of surface waters to the interior due to the water convection[12]. At the 2 km depth, ÷^{14}C value was -49.9±7.3‰ in the Area I, -53.1±5.2‰ in the Area II, and -53.7±14.5‰ in the Area III, respectively. Similarly at the 1 km depth, relatively higher ÷^{14}C values were observed at 2 km depth of the northwestern region. In the southern basin (Area III), deep water had larger variation of ÷^{14}C compared with the other regions. The result indicated that several water masses with deferent "age" coexisted in this region. In the bottom layer (3 km depth), ÷^{14}C value in the northeastern region (Area II: -63.3±6.0‰) was slightly lower than those in the northwestern and southern regions (Areas I and IV: -54.9±9.2 and -54.2±11.8‰, respectively). From these result, we inferred that the northeastern margin is a terminative region of the deepwater circulation in the Japan Sea.

4. Concluding remarks

The database for the Japan Sea Parameters on marine Environment and Radionuclides (JASPER) is created by Japan Atomic Energy Agency as one of the final products of the Japan Sea Expeditions. And now, the second volume storing data of radiocarbon and oceanographic properties is opened to the public. In this volume, totally 20,398 data records are stored including 2,695 data for temperature, 2,883 data for salinity, 2,109 data for dissolved oxygen, 11,051 data for nutrients (silicate, phosphate, nitrate, nitrite and nitrate+nitrite), and 1,660 data for radiocarbon. By establishing the second volume of database, recent feature of environment in the Japan Sea has been brought out, not only for anthropogenic radionuclides but also for other chemical tracers and oceanographic parameters. We believe that this database might be a strong tool for the continuous monitoring for contamination by anthropogenic radionuclides, studies on biogeochemical cycle, and development and validation of models for numerical simulations in the sea.

Recently, many researchers pay attention to the Japan Sea because the sea is a "miniature" of the ocean that indicates the impact of the global warming. In fact, several international expeditions in the Japan Sea are under preparation. The properties recorded in this database will also provide "historical" data for the accurate understanding of climate change.

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Table 1-1 Definition of items in the database

Column No	Column name	Content	Format*1	Error code	Remarks
1	Origin	Origin of data	I3.3	—	000: JAEA
2	Cruise	Cruise name	A10	—	
3	Sample	Sample type	A1	—	W: Seawater S: Sediment P: Sinking particle F: Filtered sample
4	Equipment	Equipment name of sampling	A10	—	
5	Stn	Site name of sampling	A8	—	
6	TD	Type definition of sampling	A1	—	S: Snapshot C: Continuous
7	SDate	Start date	I8.8	99999999	
8	STime	Start time	I4.4	9999	
9	EDate	End date	I8.8	99999999	
10	ETime	End time	I4.4	9999	
11	PDS	Position data style	I1	—	1: ddd.ddddd_X 2: ddd_mm.mm_X 3: ddd_mm_ss_X (X: N, S, E or W)
12	Lat	Latitude of sampling site (1)	A11	—	N: Northern hemisphere S: Southern hemisphere
13	zLat	Latitude of sampling site (2)	F10.6	—	+: Northern hemisphere -: Southern hemisphere
14	Lon	Longitude of sampling site (1)	A12	—	E: Eastern hemisphere W: Western hemisphere
15	zLon	Longitude of sampling site (2)	F11.6	—	+: Eastern hemisphere -: Western hemisphere
16	QF	Quality flag for position data	I1	—	1: Good 2: Suspicious 3: Bad
17	BDep	Bottom depth of sampling site [m]	I4	—	

18	BDM	Bottom depth determination method	A1	―	S: Sounding C: Chart W: Wire Z: Other
19	TSRF	Temperature and salinity reference file name	A16	―	
20	SDep	Sampling depth	I4	―	
21	SDU	Sampling depth unit	A2	―	m: Meter db: decibar
22	QF	Quality flag for sampling depth data	I1	―	1: Good 2: Suspicious 3: Bad
23	SWid	Sampling width	I4	-999	
24	SWU	Sampling width unit	A2	―	
25	QF	Quality flag for sampling width data	I1	―	1: Good 2: Suspicious 3: Bad
26	Temp	In-situ temperature [°C]	F5.2	99.99	
27	QF	Quality flag for temperature data	I1	―	1: Good 2: Suspicious 3: Bad
28	Sal	In-situ salinity [psu]	F6.3	99.999	
29	QF	Quality flag for salinity data	I1	―	1: Good 2: Suspicious 3: Bad
30	Type*2	Type of element	A1	―	R: Radionuclide N: Nutrients and oxygen
31	Element	Element name	A10	―	
32	Value	Value of measurement	Fn.m	-9999 or -999	Significant digit depends on the element
33	Error	Error of measurement	Fn.m	-999	Significant digit depends on the element

34	Unit	Unit foe the measurement	A15	－	The character "u" indicates a substituting character for prefix "micro- (10^{-6})".
35	QF	Quality flag for the element data	I1	－	1: Good 2: Suspicious 3: Bad

*1 The data format is comparable to that used in FORTRAN language. More details are defined in Table 1-2 (supplemental table).

*2 The data from "Type" to "QF" for the element data is repeated until the termination code "z" appears in the column "Type".

Table 1-2 Definition for the data format used in the database (supplemental table for Table 1-1)

Format	Expression	Example data	Example format	Result[*1]
An	Alphabetic numeric character less than n characters	abc_123	A10	･･･abc_123 or abc_123･･･
In	Integer number less than n digits	72	I5	･･･72
Fm.n	Real number less than m digits with n-digit decimal number	72	F5.1	･72.0

*1 The symbol of centered dot (･) indicates blank equivalent to 1 character

Table 2 Information about research cruises and sampling stations

Cruise	Station	Date	Longitude [°E]	Latitude [°N]	Bottom depth [m]	Area*	Ship
WS9802	C1	10/31/1998	136.383	39.617	2519	3	R/V Wakashio-Maru
WS9802	C2	10/30/1998	136.700	39.380	2657	3	R/V Wakashio-Maru
WS9802	C3	10/30/1998	137.033	39.150	2421	3	R/V Wakashio-Maru
WS9802	C4	10/29/1998	137.380	38.920	2387	3	R/V Wakashio-Maru
WS9802	C5	10/29/1998	137.700	38.680	2330	3	R/V Wakashio-Maru
XP99	E08	5/31/1999	135.100	40.433	2540	1	R/V Professor Khromov
XP99	E10	5/27/1999	134.480	41.252	3560	1	R/V Professor Khromov
XP99	F14	5/29/1999	132.350	40.998	3420	1	R/V Professor Khromov
XP99	F15	5/30/1999	132.755	40.600	3430	1	R/V Professor Khromov
XP99	F16	5/30/1999	133.128	40.217	3310	1	R/V Professor Khromov
XP99	F17	5/31/1999	133.533	39.833	1260	1	R/V Professor Khromov
XP99	E09	5/31/1999	134.017	40.833	3340	1	R/V Professor Khromov
WS9901	E1	06/25/1999	134.500	36.500	1344	3	R/V Wakashio-Maru
WS9901	E3	06/25/1999	134.000	37.000	1863	3	R/V Wakashio-Maru
WS9901	E4	06/26/1999	133.500	37.500	1430	3	R/V Wakashio-Maru
WS9901	E6	06/26/1999	133.000	38.000	2508	3	R/V Wakashio-Maru
WS9901	W1	06/23/1999	132.830	36.500	250	4	R/V Wakashio-Maru
WS9901	W3	06/23/1999	132.330	37.000	1250	4	R/V Wakashio-Maru
WS9902	D1	11/23/1999	134.667	38.700	3013	3	R/V Wakashio-Maru
WS9902	D2	11/23/1999	135.083	38.300	3014	3	R/V Wakashio-Maru
WS9902	D3	11/24/1999	135.467	37.917	2960	3	R/V Wakashio-Maru
WS9902	D4	11/24/1999	135.833	37.550	2419	3	R/V Wakashio-Maru
WS9902	D5	11/24/1999	136.233	37.150	359	3	R/V Wakashio-Maru
XP00	C1	8/7/2000	131.667	40.000	3000	1	R/V Professor Khromov
XP00	C2	8/7/2000	131.667	40.500	3290	1	R/V Professor Khromov
XP00	C3	8/6/2000	131.667	41.000	3300	1	R/V Professor Khromov
XP00	C4	8/6/2000	131.667	41.667	3270	1	R/V Professor Khromov
XP00	C5	8/8/2000	132.333	41.000	3400	1	R/V Professor Khromov
XP00	C6	8/8/2000	132.750	40.583	3380	1	R/V Professor Khromov
XP00	C7	8/9/2000	133.133	40.217	3260	1	R/V Professor Khromov
XP00	C8	8/10/2000	133.500	40.000	1630	1	R/V Professor Khromov
XP00	C9	8/10/2000	133.500	40.500	3390	1	R/V Professor Khromov
XP00	C10	8/11/2000	133.500	41.000	3500	1	R/V Professor Khromov
XP00	C11	8/11/2000	133.500	41.667	3230	1	R/V Professor Khromov

XP00	M2	8/12/2000	135.000	40.500	2860	1	R/V Professor Khromov
XP00	E2	8/13/2000	135.000	41.283	3580	1	R/V Professor Khromov
XP00	E3	8/13/2000	135.000	41.667	3560	1	R/V Professor Khromov
HO00	106d	9/28/2000	135.000	38.000	2988	3	T/S Hokusei Maru
HO00	107d	9/28/2000	134.743	39.198	312	3	T/S Hokusei Maru
HO00	108d	9/29/2000	135.000	39.000	2917	3	T/S Hokusei Maru
HO00	109d	9/29/2000	135.500	37.416	2884	3	T/S Hokusei Maru
HO00	111d	10/3/2000	138.000	39.000	1664	3	T/S Hokusei Maru
HO00	114d	10/5/2000	138.485	42.315	3642	2	T/S Hokusei Maru
WS00	E1	10/20/2000	131.667	36.500	1876	3	R/V Wakashio-Maru
WS00	E2	10/20/2000	131.667	36.000	1061	3	R/V Wakashio-Maru
WS00	E3	10/17/2000	133.500	38.500	1315	3	R/V Wakashio-Maru
WS00	E4	10/17/2000	133.500	38.000	872	3	R/V Wakashio-Maru
WS00	E5	10/19/2000	133.500	37.000	360	3	R/V Wakashio-Maru
WS00	E6	10/19/2000	133.500	36.000	172	4	R/V Wakashio-Maru
XP01	c3	7/5/2001	133.133	40.215	3312	1	R/V Professor Khromov
XP01	c2	7/6/2001	132.747	40.583	3427	1	R/V Professor Khromov
XP01	r1	7/7/2001	133.338	41.665	3518	1	R/V Professor Khromov
XP01	c7	7/8/2001	136.520	41.993	3612	2	R/V Professor Khromov
XP01	c15	7/12/2001	137.998	45.498	1418	2	R/V Professor Khromov
XP01	c13	7/13/2001	138.002	44.498	2605	2	R/V Professor Khromov
XP01	c12	7/13/2001	138.000	43.998	2235	2	R/V Professor Khromov
XP01	c11	7/13/2001	136.490	44.000	1114	2	R/V Professor Khromov
XP01	c9	7/14/2001	136.505	42.995	3636	2	R/V Professor Khromov
XP01	c8	7/14/2001	136.503	42.498	3665	2	R/V Professor Khromov
XP01	c6	7/15/2001	135.000	42.997	2260	1	R/V Professor Khromov
XP01	c4	7/15/2001	135.000	42.000	3610	1	R/V Professor Khromov
XP01	C1	7/3/2001	132.337	40.995	3420	1	R/V Professor Khromov
HO01	J32d	9/19/2001	131.000	36.750	2125	4	T/S Hokusei Maru
KK01	F2	10/31/2001	138.000	42.500	3600	2	R/V Kaiko Maru No.12
KK01	F6	10/31/2001	139.000	42.500	3649	2	R/V Kaiko Maru No.12
KK01	F7	10/31/2001	139.000	41.500	1315	2	R/V Kaiko Maru No.12
KK01	F8	11/2/2001	139.000	40.500	3138	2	R/V Kaiko Maru No.12
XP02	m2	7/7/2002	135.000	40.500	2905	1	R/V Professor Khromov
XP02	c1	7/8/2002	131.665	41.250	3346	1	R/V Professor Khromov
XP02	ms	7/8/2002	132.350	41.252	3426	1	R/V Professor Khromov

XP02	c2	7/9/2002	132.998	41.250	3474	1	R/V Professor Khromov
XP02	r1	7/10/2002	133.498	41.252	3506	1	R/V Professor Khromov
XP02	c4	7/12/2002	134.500	41.250	3563	1	R/V Professor Khromov
XP02	c6	7/12/2002	135.500	41.250	3563	1	R/V Professor Khromov
XP02	r2	7/13/2002	136.533	42.013	3623	2	R/V Professor Khromov
XP02	c13	7/17/2002	139.497	47.015	575	2	R/V Professor Khromov
XP02	c15	7/17/2002	140.450	47.003	1216	2	R/V Professor Khromov
XP02	c17	7/18/2002	141.501	47.000	605	2	R/V Professor Khromov
XP02	c12	7/18/2002	141.500	46.000	113	2	R/V Professor Khromov
XP02	c10	7/18/2002	140.495	46.000	1055	2	R/V Professor Khromov
XP02	c9	7/18/2002	139.498	46.000	1804	2	R/V Professor Khromov
XP02	c7	7/19/2002	138.498	46.000	1260	2	R/V Professor Khromov
XP02	r3	7/20/2002	137.952	44.012	2223	2	R/V Professor Khromov
KH02-03	c01	10/14/2002	131.523	36.036	1342	4	R/V Hakuho Maru
KH02-03	c02	10/14/2002	132.255	36.335	1412	4	R/V Hakuho Maru
KH02-03	c03	10/15/2002	133.671	36.666	1120	3	R/V Hakuho Maru
KH02-03	c04	10/15/2002	134.247	37.218	2351	3	R/V Hakuho Maru
KH02-03	c05	10/15/2002	134.800	37.722	2947	3	R/V Hakuho Maru
KH02-03	c06	10/15/2002	135.362	38.230	2930	3	R/V Hakuho Maru
KH02-03	c07	10/16/2002	135.909	38.642	2705	3	R/V Hakuho Maru
KH02-03	c08	10/16/2002	136.322	39.114	2612	3	R/V Hakuho Maru
KH02-03	c09	10/16/2002	136.611	39.369	2647	3	R/V Hakuho Maru
KH02-03	c10	10/16/2002	136.975	39.550	2580	3	R/V Hakuho Maru
KH02-03	c11	10/17/2002	137.327	39.726	2571	3	R/V Hakuho Maru
KH02-03	c12	10/17/2002	137.894	39.960	2668	3	R/V Hakuho Maru
KH02-03	c13	10/17/2002	137.895	40.461	3047	2	R/V Hakuho Maru
KH02-03	c14	10/18/2002	137.895	40.956	3636	2	R/V Hakuho Maru
KH02-03	c15	10/18/2002	137.891	41.457	3660	2	R/V Hakuho Maru
KH02-03	c16	10/18/2002	137.884	41.957	3623	2	R/V Hakuho Maru
KH02-03	c17	10/18/2002	138.218	42.577	3643	2	R/V Hakuho Maru
KH02-03	c18	10/19/2002	138.576	43.200	3520	2	R/V Hakuho Maru
7K02	C3	10/31/2002	137.033	39.150	2466	3	R/V Kaiyo Maru No.7
7K02	D5	11/1/2002	136.233	37.150	372	3	R/V Kaiyo Maru No.7
7K02	E1	11/6/2002	131.667	36.500	1905	4	R/V Kaiyo Maru No.7
7K02	E2	11/6/2002	131.667	36.000	1061	4	R/V Kaiyo Maru No.7
7K02	E3	11/7/2002	133.500	38.500	1315	3	R/V Kaiyo Maru No.7

SY04	JS1	7/23/2004	137.970	40.990	3745	2	R/V Soyo Maru
SY04	JS2	7/25/2004	134.270	39.050	355	3	R/V Soyo Maru
SY04	JS3	7/29/2004	134.020	37.716	1588	3	R/V Soyo Maru
SY04	JS4	7/29/2004	135.000	38.836	3000	3	R/V Soyo Maru
SY05	M1	7/13/2005	139.837	41.002	1356	2	R/V Soyo Maru
SY05	M3	7/15/2005	137.968	41.012	3623	2	R/V Soyo Maru
SY05	M5	7/16/2005	136.265	40.998	3352	2	R/V Soyo Maru
SY05	M6	7/17/2005	138.012	43.017	3623	2	R/V Soyo Maru
SY05	M8	7/18/2005	139.002	43.002	3516	2	R/V Soyo Maru
SY05	M10	7/18/2005	140.000	43.000	1188	2	R/V Soyo Maru
SY05	M12	7/19/2005	139.050	44.501	1127	2	R/V Soyo Maru
SY05	M14	7/19/2005	140.002	44.501	550	2	R/V Soyo Maru
SY05	M16	7/19/2005	141.000	44.500	193	2	R/V Soyo Maru
SY05	M21	7/22/2005	141.500	45.583	121	2	R/V Soyo Maru
SY05	M23	7/22/2005	139.998	45.585	542	2	R/V Soyo Maru
SY05	M24	7/26/2005	139.995	43.005	1233	2	R/V Soyo Maru
SY05	M25	7/28/2005	137.133	40.152	1732	2	R/V Soyo Maru
SY05	M26	7/30/3005	136.141	39.896	1363	3	R/V Soyo Maru
SY05	M27	7/31/2005	135.267	39.418	282	3	R/V Soyo Maru
OS05	JS1S	10/25/2005	137.263	39.649	2602	3	T/S Oshoro Maru
OS05	JS1D	10/25/2005	137.263	39.649	2602	3	T/S Oshoro Maru
SY06	Cn1	7/21/2006	138.000	41.833	3699	2	R/V Soyo Maru
SY06	Cn2	7/21/2006	139.000	41.833	2328	2	R/V Soyo Maru
SY06	Cn3	7/21/2006	139.833	41.833	1388	2	R/V Soyo Maru
SY06	Cw2_Cs3	7/22/2006	139.797	40.627	440	2	R/V Soyo Maru
SY06	Cs2	7/22/2006	139.000	40.791	3348	2	R/V Soyo Maru
SY06	Trap	7/31/2006	138.000	41.000	3629	2	R/V Soyo Maru
SY06	YR	7/31/2006	135.667	39.417	367	3	R/V Soyo Maru
SY06	YB	8/2/2006	135.752	38.503	2950	3	R/V Soyo Maru
SY06	Notooki	8/3/2006	136.417	37.667	197	3	R/V Soyo Maru
SY06	Tg_LV	7/20/2006	140.536	41.585	-999	2	R/V Soyo Maru
SY06	YR_LV_1	7/31/2006	135.667	39.417	367	3	R/V Soyo Maru
SY06	YB_LV1	8/2/2006	135.752	38.503	2950	3	R/V Soyo Maru
SY06	Notooki	8/3/2006	136.417	37.667	197	3	R/V Soyo Maru
KO06	B3	10/16/2006	138.005	37.745	1610	3	R/V Koshiji Maru
KO06	B5	10/17/2006	138.011	37.494	1125	3	R/V Koshiji Maru

KO06	B9	10/18/2006	138.245	37.395	255	3	R/V Koshiji Maru
SY07	Trap	7/20/2007	138.005	41.001	3624	2	R/V Soyo Maru
SY07	YB	7/23/2007	135.008	38.495	2966	3	R/V Soyo Maru
SY07	YB_ent	7/20/2007	137.169	39.749	2567	3	R/V Soyo Maru
SY07	YR_D	7/22/2007	135.227	39.402	306	3	R/V Soyo Maru
SY07	YR_surf	7/22/2007	135.227	39.402	306	3	R/V Soyo Maru
SY07	KG2	7/21/2007	136.114	39.929	1334	3	R/V Soyo Maru
SY07	KG3	7/20/2007	137.122	40.093	1787	2	R/V Soyo Maru
OS07	5d	11/5/2007	138.337	41.994	3683	2	T/S Oshoro Maru
OS07	6d	11/6/2007	137.685	41.192	3678	2	T/S Oshoro Maru
OS07	13d	11/7/2007	137.686	39.983	2700	3	T/S Oshoro Maru
OS07	25d	11/8/2007	136.675	39.344	2656	3	T/S Oshoro Maru
OS07	21d	11/9/2007	135.499	38.470	3002	3	T/S Oshoro Maru
SY08	TB	7/30/2008	132.345	36.185	1146	4	R/V Soyo Maru
SY08	YB	7/26/2008	134.998	38.500	2965	3	R/V Soyo Maru
SY08	YR	7/25/2008	135.667	39.417	367	3	R/V Soyo Maru
SY09	Trap	7/21/2009	138.002	41.000	3675	2	R/V Soyo Maru
SY09	YBLV1	7/24/2009	134.998	38.497	2963	3	R/V Soyo Maru
SY09	JB1LV1	7/26/2009	137.998	42.998	3625	2	R/V Soyo Maru

* Corresponds to area in Fig. 1

Table 3 Statistical values of the data for radiocarbon and oceanographic properties

	Sal	Temp	Oxy	Si	P	NO_3	NO_2	NO_x	÷^{14}C
Number of data									
Good	2881	2695	2096	2332	2316	1685	1982	2025	1572
	(94.1)	(88.0)	(68.5)	(76.2)	(75.6)	(55.0)	(64.7)	(66.1)	(51.3)
Suspicious	2	0	13	12	0	302	0	295	84
	(0.1)	(0.0)	(0.4)	(0.4)	(0.0)	(9.9)	(0.0)	(9.6)	(2.7)
Bad*	179	367	953	718	746	1075	1080	742	1406
	(5.8)	(12.0)	(31.1)	(23.4)	(24.4)	(35.1)	(35.3)	(24.2)	(45.9)
Total	3062	3062	3062	3062	3062	3062	3062	3062	3062
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Data									
Maximum**	35.129	32.872	8.312	97.3	2.22	27.7	1.00	28.5	95.9
Minimum**	32.639	0.051	3.538	0.0	0.00	0.0	0.00	0.0	-76.1
Unit	psu	°C	ml/l	μmol/l	μmol/l	μmol/l	μmol/l	μmol/l	‰

Values in brackets are the percentage for the number of data in each type of sample.

* Including number of samples that sub-sampling or measurement was not carried out.

** Not including data categorized in "Suspicious" and "Bad" criteria.

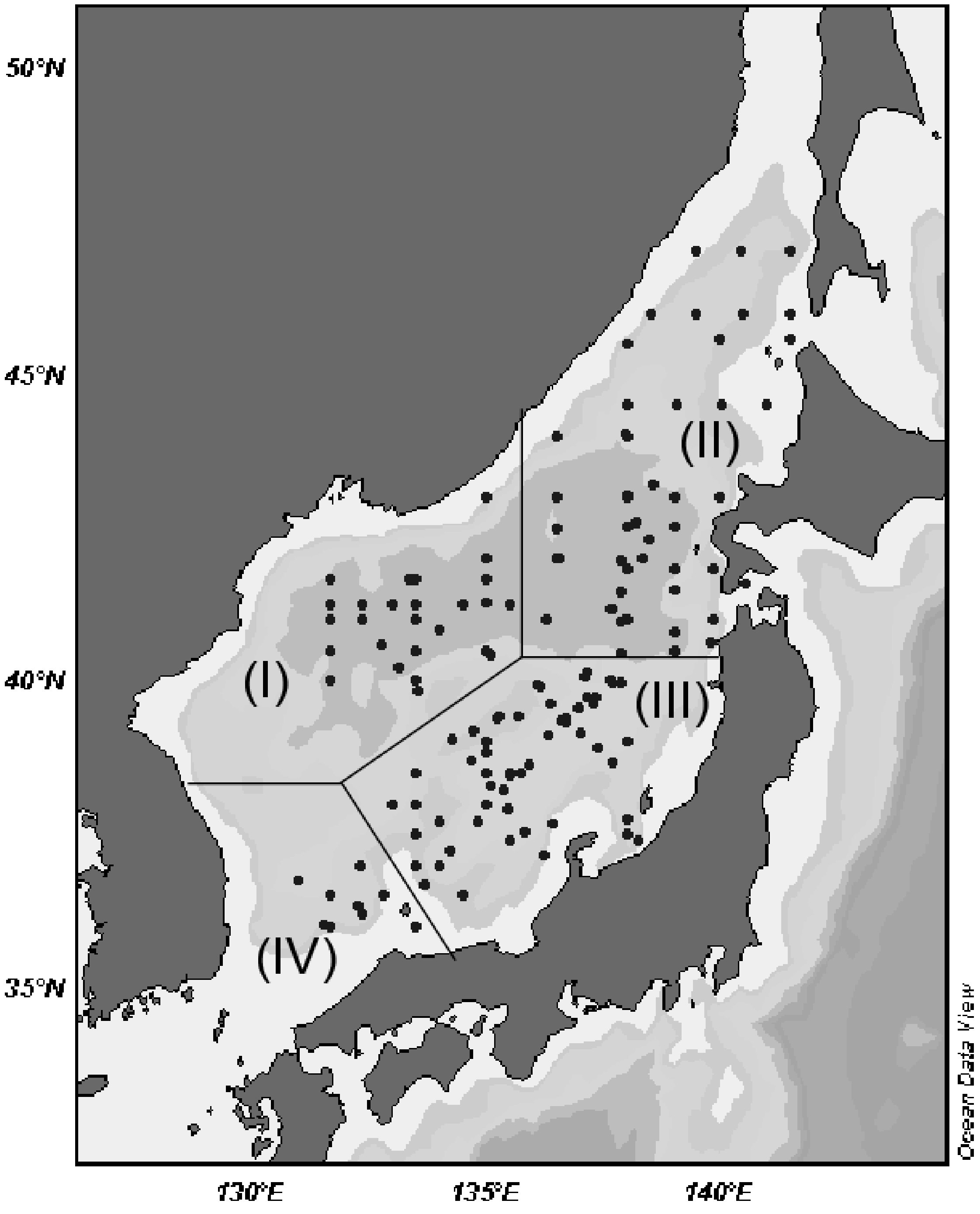

Fig. 1 Sampling stations

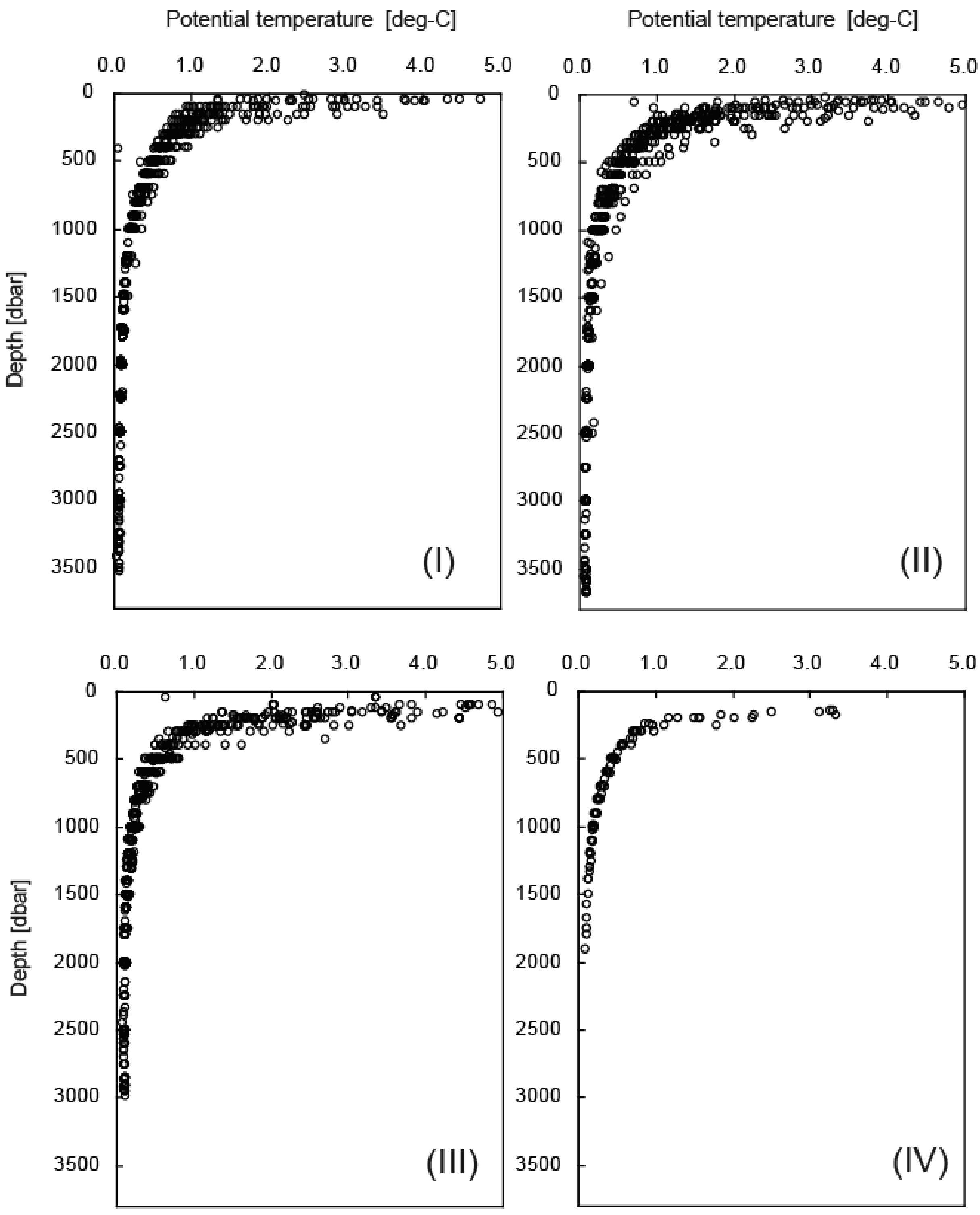

Fig. 2 Vertical distributions of potential temperature. I-IV correspond to regions in Fig. 1.

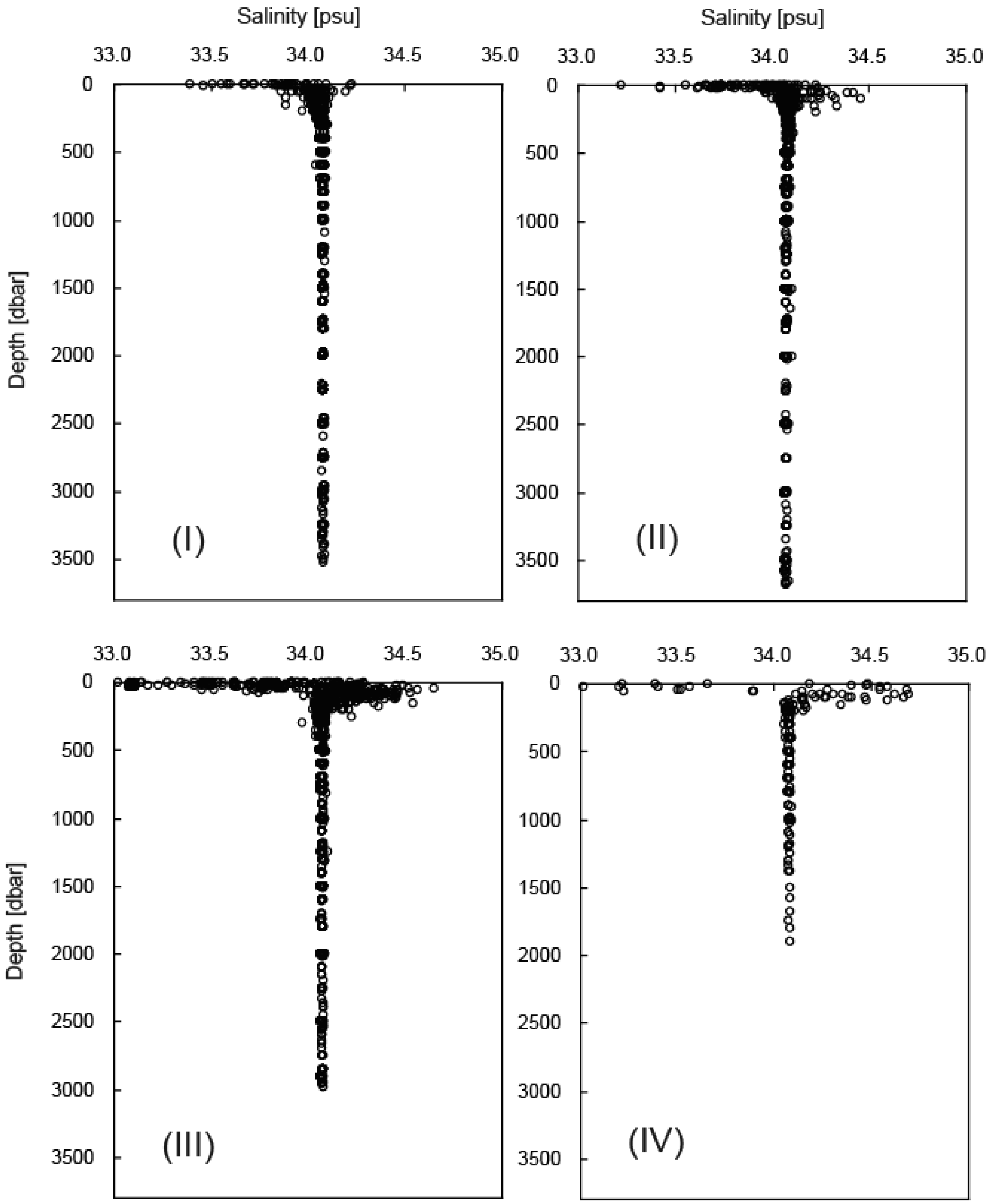

Fig. 3 Vertical distributions of salinity. I-IV correspond to regions in Fig. 1.

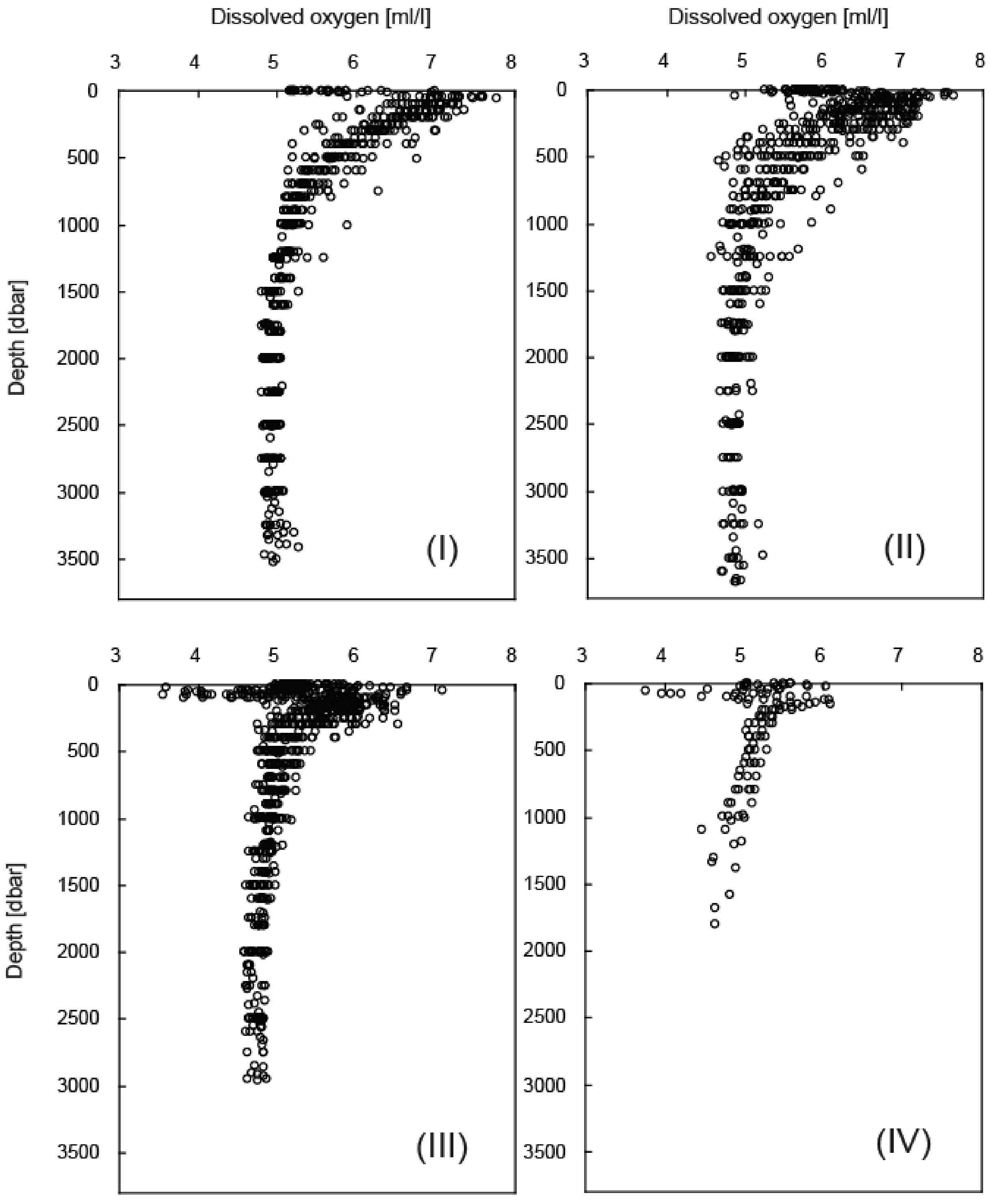

Fig. 4 Vertical distributions of dissolved oxygen. I-IV correspond to regions in Fig. 1.

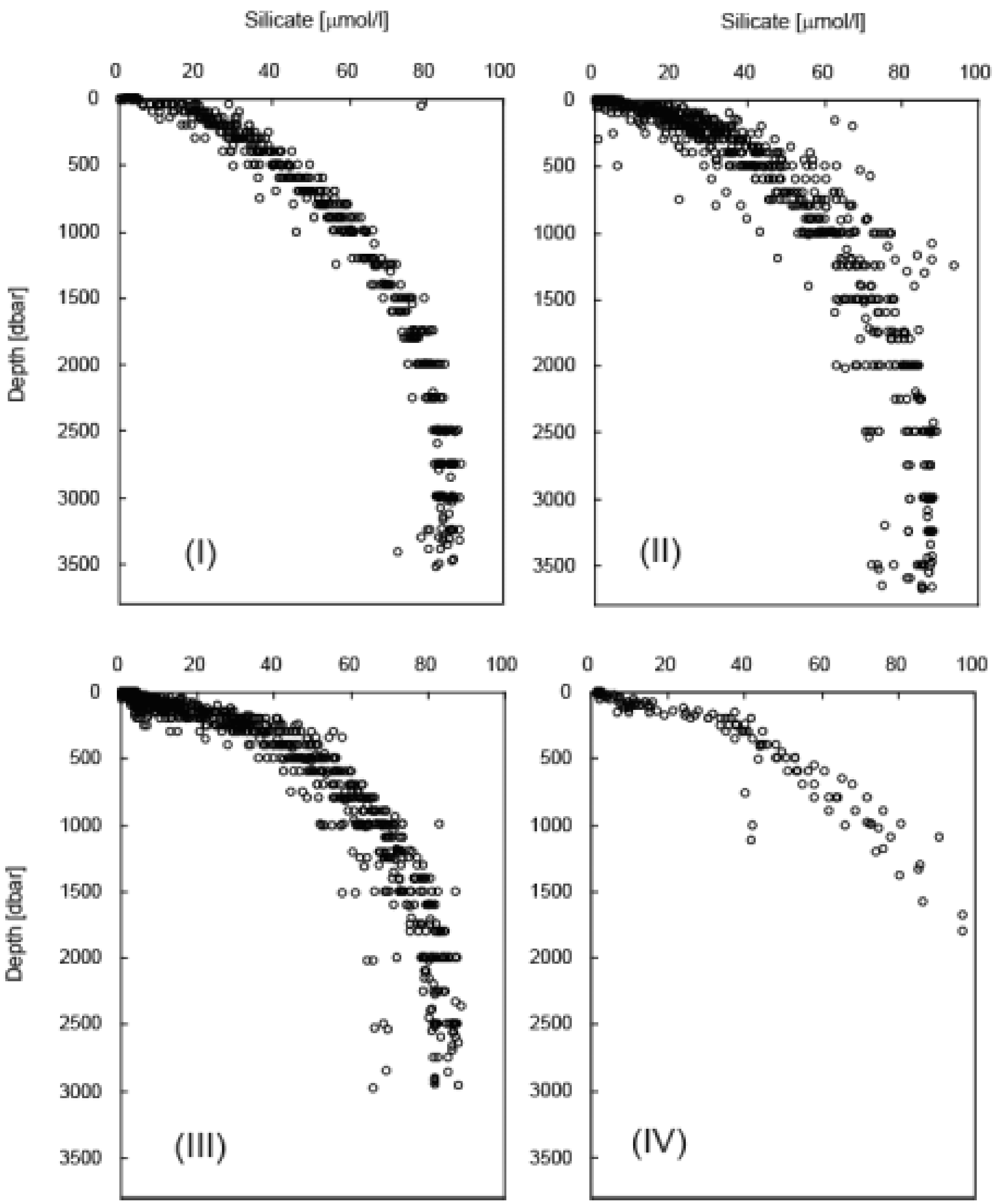

Fig. 5 Vertical distributions of silicate. I-IV correspond to regions in Fig. 1.

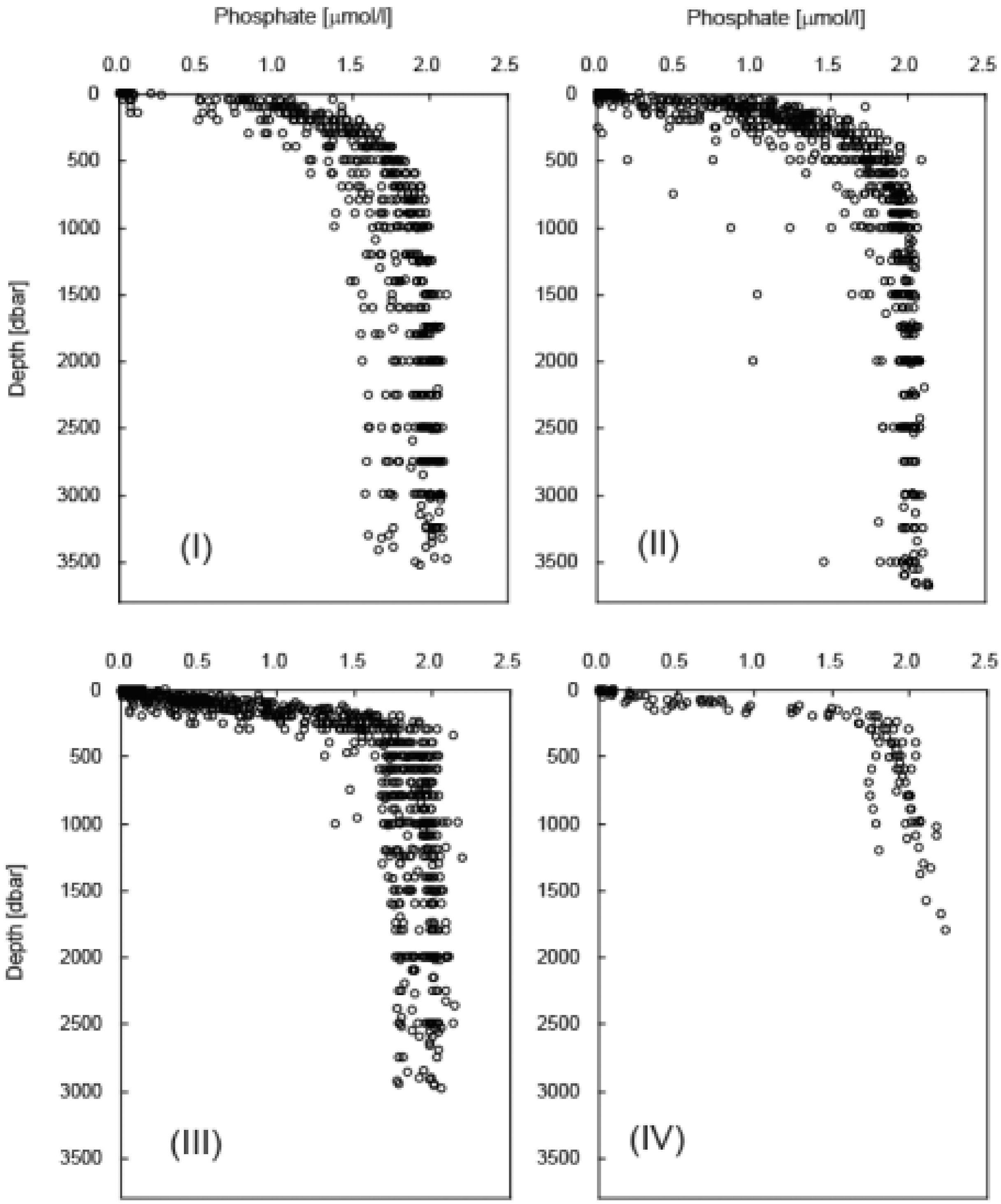

Fig. 6　Vertical distributions of phosphate.　I-IV correspond to regions in Fig. 1.

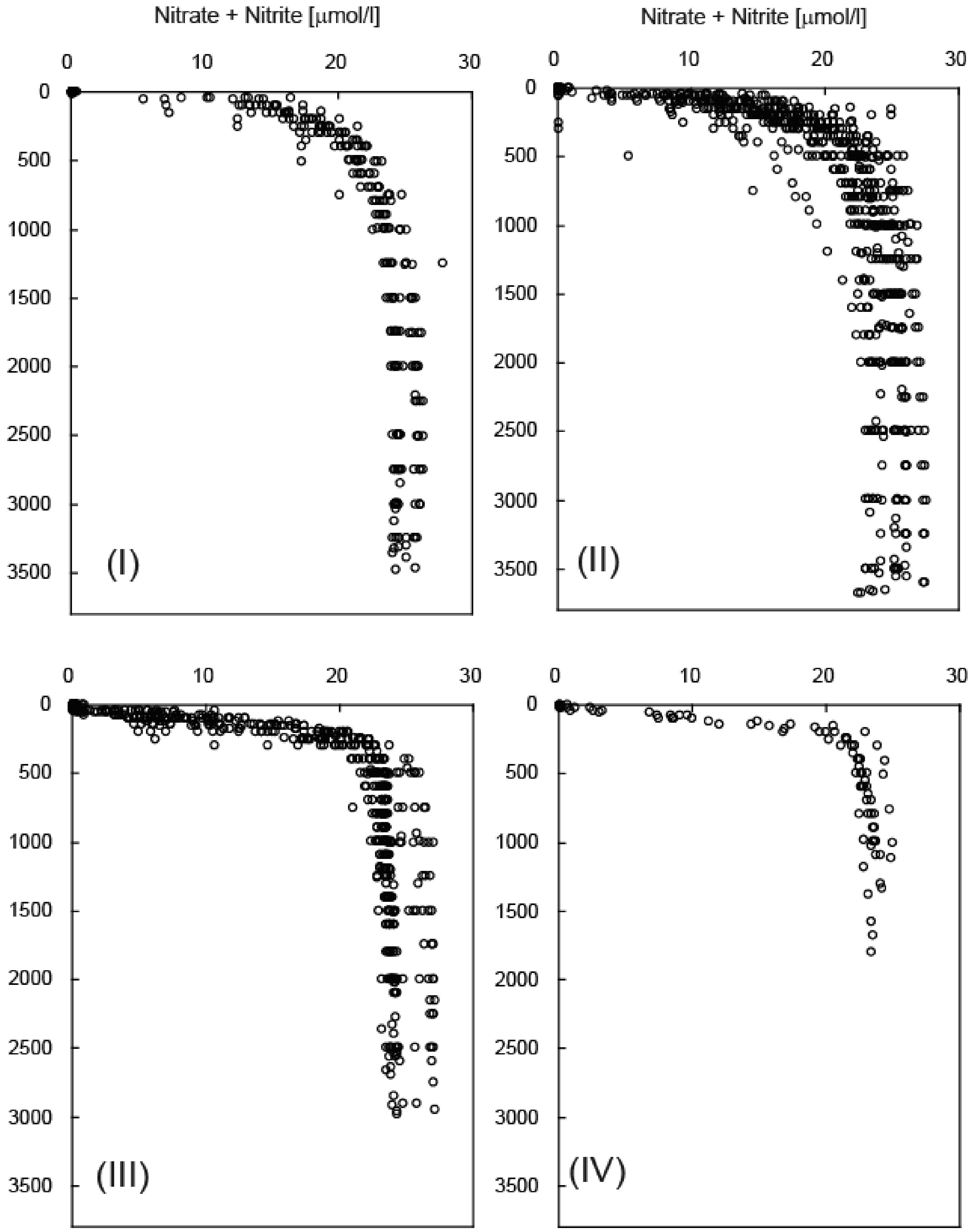

Fig. 7 Vertical distributions of total nitrogen (nitrate and nitrite).
I-IV correspond to regions in Fig. 1.

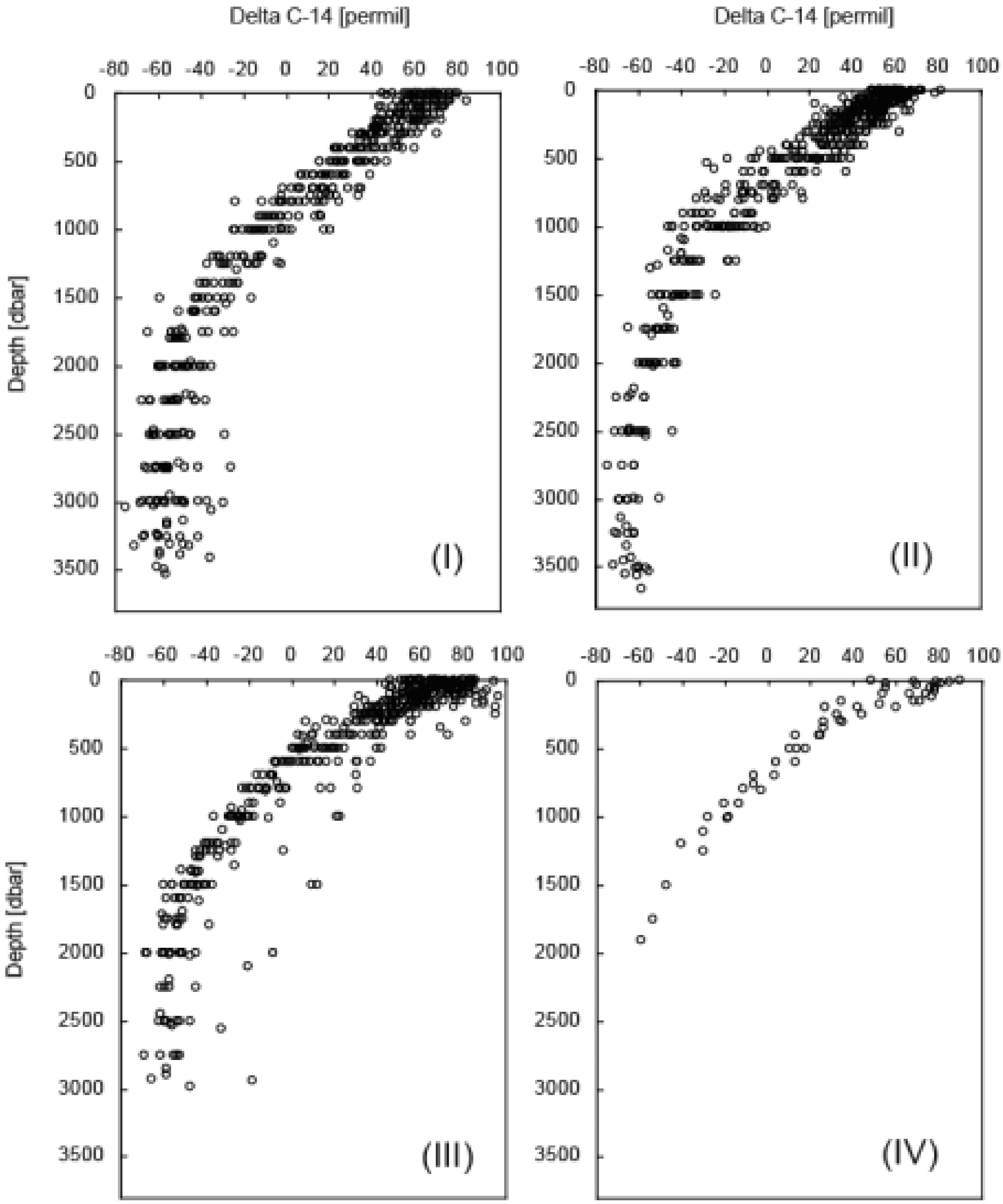

Fig. 8 Vertical distributions of ÷^{14}C. I-IV correspond to regions in Fig. 1.

国際単位系（SI）

表１．SI 基本単位

基本量	SI 基本単位	
	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光度	カンデラ	cd

表２．基本単位を用いて表されるSI組立単位の例

組立量	SI 基本単位	
	名称	記号
面積	平方メートル	m^2
体積	立法メートル	m^3
速さ，速度	メートル毎秒	m/s
加速度	メートル毎秒毎秒	m/s^2
波数	毎メートル	m^{-1}
密度，質量密度	キログラム毎立方メートル	kg/m^3
面積密度	キログラム毎平方メートル	kg/m^2
比体積	立方メートル毎キログラム	m^3/kg
電流密度	アンペア毎平方メートル	A/m^2
磁界の強さ	アンペア毎メートル	A/m
量濃度 (a)，濃度	モル毎立方メートル	mol/m^3
質量濃度	キログラム毎立法メートル	kg/m^3
輝度	カンデラ毎平方メートル	cd/m^2
屈折率 (b)	（数字の）1	1
比透磁率 (b)	（数字の）1	1

(a) 量濃度（amount concentration）は臨床化学の分野では物質濃度（substance concentration）ともよばれる。
(b) これらは無次元量あるいは次元１をもつ量であるが、そのことを表す単位記号である数字の１は通常は表記しない。

表３．固有の名称と記号で表されるSI組立単位

組立量	SI 組立単位			
	名称	記号	他のSI単位による表し方	SI基本単位による表し方
平面角	ラジアン(b)	rad	1 (b)	m/m
立体角	ステラジアン(b)	sr(c)	1 (b)	m^{2}/m^2
周波数	ヘルツ (d)	Hz		s^{-1}
力	ニュートン	N		$m\ kg\ s^{-2}$
圧力，応力	パスカル	Pa	N/m^2	$m^{-1}\ kg\ s^{-2}$
エネルギー，仕事，熱量	ジュール	J	N m	$m^2\ kg\ s^{-2}$
仕事率，工率，放射束	ワット	W	J/s	$m^2\ kg\ s^{-3}$
電荷，電気量	クーロン	C		s A
電位差（電圧），起電力	ボルト	V	W/A	$m^2\ kg\ s^{-3}\ A^{-1}$
静電容量	ファラド	F	C/V	$m^{-2}\ kg^{-1}\ s^4\ A^2$
電気抵抗	オーム	Ω	V/A	$m^2\ kg\ s^{-3}\ A^{-2}$
コンダクタンス	ジーメンス	S	A/V	$m^{-2}\ kg^{-1}\ s^3\ A^2$
磁束	ウエーバ	Wb	Vs	$m^2\ kg\ s^{-2}\ A^{-1}$
磁束密度	テスラ	T	Wb/m^2	$kg\ s^{-2}\ A^{-1}$
インダクタンス	ヘンリー	H	Wb/A	$m^2\ kg\ s^{-2}\ A^{-2}$
セルシウス温度	セルシウス度(e)	℃		K
光束	ルーメン	lm	cd sr(c)	cd
照度	ルクス	lx	lm/m^2	$m^{-2}\ cd$
放射性核種の放射能 (f)	ベクレル (d)	Bq		s^{-1}
吸収線量, 比エネルギー分与, カーマ	グレイ	Gy	J/kg	$m^2\ s^{-2}$
線量当量, 周辺線量当量, 方向性線量当量, 個人線量当量	シーベルト (g)	Sv	J/kg	$m^2\ s^{-2}$
酸素活性	カタール	kat		$s^{-1}\ mol$

(a)SI接頭語は固有の名称と記号を持つ組立単位と組み合わせても使用できる。しかし接頭語を付した単位はもはやコヒーレントではない。
(b)ラジアンとステラジアンは数字の１に対する単位の特別な名称で、量についての情報をつたえるために使われる。実際には、使用する時には記号rad及びsrが用いられるが、習慣として組立単位としての記号である数字の１は明示されない。
(c)測光学ではステラジアンという名称と記号srを単位の表し方の中に、そのまま維持している。
(d)ヘルツは周期現象についてのみ、ベクレルは放射性核種の統計的過程についてのみ使用される。
(e)セルシウス度はケルビンの特別な名称で、セルシウス温度を表すために使用される。セルシウス度とケルビンの単位の大きさは同一である。したがって、温度差や温度間隔を表す数値はどちらの単位で表しても同じである。
(f)放射性核種の放射能（activity referred to a radionuclide）は、しばしば誤った用語で”radioactivity”と記される。
(g)単位シーベルト（PV,2002,70,205）についてはCIPM勧告2（CI-2002）を参照。

表４．単位の中に固有の名称と記号を含むSI組立単位の例

組立量	SI 組立単位		
	名称	記号	SI 基本単位による表し方
粘度	パスカル秒	Pa s	$m^{-1}\ kg\ s^{-1}$
力のモーメント	ニュートンメートル	N m	$m^2\ kg\ s^{-2}$
表面張力	ニュートン毎メートル	N/m	$kg\ s^{-2}$
角速度	ラジアン毎秒	rad/s	$m\ m^{-1}\ s^{-1}=s^{-1}$
角加速度	ラジアン毎秒毎秒	rad/s^2	$m\ m^{-1}\ s^{-2}=s^{-2}$
熱流密度，放射照度	ワット毎平方メートル	W/m^2	$kg\ s^{-3}$
熱容量，エントロピー	ジュール毎ケルビン	J/K	$m^2\ kg\ s^{-2}\ K^{-1}$
比熱容量，比エントロピー	ジュール毎キログラム毎ケルビン	J/(kg K)	$m^2\ s^{-2}\ K^{-1}$
比エネルギー	ジュール毎キログラム	J/kg	$m^2\ s^{-2}$
熱伝導率	ワット毎メートル毎ケルビン	W/(m K)	$m\ kg\ s^{-3}\ K^{-1}$
体積エネルギー	ジュール毎立方メートル	J/m^3	$m^{-1}\ kg\ s^{-2}$
電界の強さ	ボルト毎メートル	V/m	$m\ kg\ s^{-3}\ A^{-1}$
電荷密度	クーロン毎立方メートル	C/m^3	$m^{-3}\ sA$
表面電荷	クーロン毎平方メートル	C/m^2	$m^{-2}\ sA$
電束密度，電気変位	クーロン毎平方メートル	C/m^2	$m^{-2}\ sA$
誘電率	ファラド毎メートル	F/m	$m^{-3}\ kg^{-1}\ s^4\ A^2$
透磁率	ヘンリー毎メートル	H/m	$m\ kg\ s^{-2}\ A^{-2}$
モルエネルギー	ジュール毎モル	J/mol	$m^2\ kg\ s^{-2}\ mol^{-1}$
モルエントロピー, モル熱容量	ジュール毎モル毎ケルビン	J/(mol K)	$m^2\ kg\ s^{-2}\ K^{-1}\ mol^{-1}$
照射線量（Ｘ線及びγ線）	クーロン毎キログラム	C/kg	$kg^{-1}\ sA$
吸収線量率	グレイ毎秒	Gy/s	$m^2\ s^{-3}$
放射強度	ワット毎ステラジアン	W/sr	$m^4\ m^{-2}\ kg\ s^{-3}=m^2\ kg\ s^{-3}$
放射輝度	ワット毎平方メートル毎ステラジアン	$W/(m^2\ sr)$	$m^2\ m^{-2}\ kg\ s^{-3}=kg\ s^{-3}$
酵素活性濃度	カタール毎立方メートル	kat/m^3	$m^{-3}\ s^{-1}\ mol$

表５．SI 接頭語

乗数	接頭語	記号	乗数	接頭語	記号
10^{24}	ヨタ	Y	10^{-1}	デシ	d
10^{21}	ゼタ	Z	10^{-2}	センチ	c
10^{18}	エクサ	E	10^{-3}	ミリ	m
10^{15}	ペタ	P	10^{-6}	マイクロ	µ
10^{12}	テラ	T	10^{-9}	ナノ	n
10^{9}	ギガ	G	10^{-12}	ピコ	p
10^{6}	メガ	M	10^{-15}	フェムト	f
10^{3}	キロ	k	10^{-18}	アト	a
10^{2}	ヘクト	h	10^{-21}	ゼプト	z
10^{1}	デカ	da	10^{-24}	ヨクト	y

表６．SIに属さないが、SIと併用される単位

名称	記号	SI 単位による値
分	min	1 min=60s
時	h	1h =60 min=3600 s
日	d	1 d=24 h=86 400 s
度	°	1°=(π/180) rad
分	’	1’=(1/60)°=(π/10800) rad
秒	”	1”=(1/60)’=(π/648000) rad
ヘクタール	ha	$1ha=1hm^2=10^4m^2$
リットル	L，l	$1L=1l=1dm^3=10^3cm^3=10^{-3}m^3$
トン	t	$1t=10^3\ kg$

表７．SIに属さないが、SIと併用される単位で、SI単位で表される数値が実験的に得られるもの

名称	記号	SI 単位で表される数値
電子ボルト	eV	$1eV=1.602\ 176\ 53(14)\times10^{-19}J$
ダルトン	Da	$1Da=1.660\ 538\ 86(28)\times10^{-27}kg$
統一原子質量単位	u	1u=1 Da
天文単位	ua	$1ua=1.495\ 978\ 706\ 91(6)\times10^{11}m$

表８．SIに属さないが、SIと併用されるその他の単位

名称	記号	SI 単位で表される数値
バール	bar	$1\ bar=0.1MPa=100kPa=10^5Pa$
水銀柱ミリメートル	mmHg	1mmHg=133.322Pa
オングストローム	Å	$1\ Å=0.1nm=100pm=10^{-10}m$
海里	M	1 M=1852m
バーン	b	$1\ b=100fm^2=(10^{-12}cm)2=10^{-28}m^2$
ノット	kn	1 kn=(1852/3600)m/s
ネーパ	Np	SI単位との数値的な関係は、対数量の定義に依存。
ベル	B	
デジベル	dB	

表９．固有の名称をもつCGS組立単位

名称	記号	SI 単位で表される数値
エルグ	erg	$1\ erg=10^{-7}\ J$
ダイン	dyn	$1\ dyn=10^{-5}N$
ポアズ	P	$1\ P=1\ dyn\ s\ cm^{-2}=0.1Pa\ s$
ストークス	St	$1\ St=1cm^2\ s^{-1}=10^{-4}m^2\ s^{-1}$
スチルブ	sb	$1\ sb=1cd\ cm^{-2}=10^4cd\ m^{-2}$
フォト	ph	$1\ ph=1cd\ sr\ cm^{-2}\ 10^4lx$
ガル	Gal	$1\ Gal=1cm\ s^{-2}=10^{-2}ms^{-2}$
マクスウェル	Mx	$1\ Mx=1G\ cm^2=10^{-8}Wb$
ガウス	G	$1\ G=1Mx\ cm^{-2}=10^{-4}T$
エルステッド (c)	Oe	$1\ Oe \triangleq (10^3/4\pi)A\ m^{-1}$

(c) ３元系のCGS単位系とSIでは直接比較できないため、等号「 ≙ 」は対応関係を示すものである。

表10．SIに属さないその他の単位の例

名称	記号	SI 単位で表される数値
キュリー	Ci	$1\ Ci=3.7\times10^{10}Bq$
レントゲン	R	$1\ R=2.58\times10^{-4}C/kg$
ラド	rad	$1\ rad=1cGy=10^{-2}Gy$
レム	rem	$1\ rem=1\ cSv=10^{-2}Sv$
ガンマ	γ	1 γ =1 nT=10-9T
フェルミ		1フェルミ=1 fm=10-15m
メートル系カラット		1メートル系カラット = 200 mg = 2×10-4kg
トル	Torr	1 Torr = (101 325/760) Pa
標準大気圧	atm	1 atm = 101 325 Pa
カロリー	cal	1cal=4.1858J（「15℃」カロリー），4.1868J（「IT」カロリー）4.184J（「熱化学」カロリー）
ミクロン	µ	$1\ \mu=1\mu m=10^{-6}m$

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