6. Survey Results in “Marine Science and Earth Science”

6.1. Trends in noteworthy domains

The “marine science and earth science” field has an intrinsically broad interdisciplinary coverage, so that trends in its closely related fields, such as “resources and energy” and “environment” must also be looked at for comparison and extra information in conducting a forecast survey, as mentioned earlier.

The global environment has various aspects and how you understand it depends on your stance. In the realm of “marine science and earth science”, focusing on topics relating to “disasters” and “education” may be one way of covering areas of attention, partly because these are closely related to people's everyday lives. (See Table 7.3-3 in Part II “Survey Results (outline)”.)

In concrete terms, the following two areas deserve close attention:

(1) Disaster prevention/preparedness technologies

Examples of topics 01, 12, 13, 14 (marine science) and 41, 45, 56, 58 and 60–63 (earth science)

(2) Human resource development and technological advancement

Examples of topics 69–74 (marine science and earth science)

In our technology forecast surveys, which are conducted every five years, the selection of questions in each survey tends to reflect the background conditions of the period in which it takes place. In the latest survey, the Great Hanshin-Awaji Earthquake, which struck southern Hyogo Prefecture in January 1995, weighed heavily. The high level of interest it aroused can be clearly seen in survey responses, as well as topic selections.

People usually talk about global environmental problems thinking only about global environmental pollution associated with human causes in some way or other. Needless to say, however, from a social safety point of view, it is highly desirable that natural disasters triggered by extreme natural phenomena, such as earthquakes, volcano eruptions, tsunamis, torrential rains and abnormal weather conditions, be included in people's perspectives. In modern times, when advanced science and technology, aging of the population and overpopulation are already facts of life, natural disasters almost always contain elements of a human disaster, and this tends to increase damage and casualties. Therefore, when examining the survey results, it is important to keep the above perspective in mind and not lose sight of the overall picture.

In this sense, the marine accident involving the Russian oil tanker “Nakhodka” in early 1997 and the ensuing wide-area oil spill disaster, which affected a wide stretch of the Sea of Japan coast, are expected to have a major impact on the selection of topics in the next survey. Because the incident is interdisciplinary in nature, it is expected to have implications for many fields, apart from “marine science and earth science”.

Topics 45–53 and 60–63 represent areas of attention relating to diastrophism. Compared to similar topics in the last survey, the forecasted realization times have been pushed back in the latest survey, and, while this is consistent with many other topics, it may reflect respondents' frustration over slower-than-expected technological progress made in these areas. Among topics that a high proportion of the respondents said “will not be realized” — a response which can be taken as a concrete expression of the above sentiment — were 60 and 61, which feature a little too optimistic propositions, and this seems to reflect respondents' realistic attitudes.

While the general high interest in disasters is not surprising, a comparison between earth science and marine science shows that attention is drawn more to observation technology for atmosphere-marine systems, which are of a global nature, permanent or rapidly expanding, than to seismic or volcanic disasters, which are one-off incidents.

In concrete terms, hopes are pinned on technologies aiming to elucidate behaviors of the atmosphere and oceans as subsystems of the hydrologic cycle that holds the key to solutions to global environmental problems. Notably, many of these technologies score over 90% for “expected effect”, and forecasted realization times generally fall into a relatively early period (around 2010) compared to other topics. This may be interpreted as

reflecting both the developmental trends of the technologies themselves and being influenced by respondents' sense of hope to a considerable degree.

In general, to solve environmental problems, the following two aspects must be given priority: concrete measures to tackle existing problems; and improvements in monitoring technologies to predict the future occurrence or spread of problems at an early stage. However, attention must be paid to the fact that, according to the observation of present social and international circumstances, progress in the former is extremely slow — so much so that even the formulation of topics regarding concrete solution technologies is not easy.

While topics relating to educational/learning institutions, such as museums and research centers, that put emphasis on academic/educational activities and systems, were chosen as proposals for the consideration of a long-term outlook, it should not be overlooked that a high proportion of respondents identified them as "effective government measures" to address the above problems". It is probably reasonable to interpret this as a sign that people involved in R&D pin their hopes on the spread of a fundamental understanding of global environmental problems through human resource development, rather than hasty Band-Aid measures.

6.1.1. Degree of importance to Japan

Overall, topics in the three fields of "marine science and earth science", "resources and energy" and "environment" as a group ranked high in terms of the degree of importance index.

Featured in the top 20 were two disaster-related topics from the "marine science and earth science" field and six nonfossil-energy-related topics from the "production and machinery", "electronics" and "materials and processing" fields. Looking to the 21st century, this clearly reflects the prevailing social trend of giving preference to technologies that are "gentle" to the global environment, and shows that a narrow perspective focusing solely on the "marine science and earth science" field would not lead to a grasp of the overall technical issues involved in global environmental problems.

In terms of the degree of importance index by field or purpose for each frame, the sea surface, atmosphere and geochemical cycle, as well as (marine) environmental conservation/creation, ranked high, as will be discussed below — highlighting the high level of interest held in topics relating to the global matter cycle, which lies at the core of global environmental problems.

6.1.2. Expected effect

A quick look at summaries of the results of the latest survey in the "marine science and earth science" field shows that forecasted realization times were pushed back, more or less following the general trend — although the recognition of its importance increased — as can be seen from a comparison with the results of the 5th Survey (last survey) for the same topics.

An examination of individual topics in terms of their expected effects, such as contribution to society and resolution of global environmental problems, brings to the fore the huge disparity between analysis results relating to topics from only the "marine science and earth science" field and the general trend of technologies relating to the Earth as a whole, as discussed above.

(1) Contribution to socioeconomic development

"Marine science and earth science", "resources and energy" and "environment", the three fields which ranked high in terms of the degree of importance in section 6.1.1., came last in terms of contribution to socioeconomic development, contrary to expectations — scoring far below the average for all 14 fields. This shows that production technologies still tend to receive disproportionate credit, highlighting a problem that exists in our preparedness for tackling global environmental issues in the future.

(2) Resolution of global-scale problems

The paradox observed in section 6.1.1. or the previous subsection, (1), is also very noticeable here. Namely, contrary to the fact that the above three fields ranked overwhelmingly high in terms of overall scores, the top 20 only contained 2 topics each from the "marine science and earth science" and "environment" fields.

(3) Response to people's needs

As a logical consequence, the above three fields ranked very low with respect to people's everyday lives. This seems to reveal a typically Japanese short-sighted attitude towards people's daily lives, driven by short-term goals and immediate gains, which have become ingrained in the national psyche and group consciousness of technically-oriented people.

(4) Expansion of human intellectual resources

Notably, while "resources and energy" and "environment" were given thumbs down in terms of the expansion of human intellectual resources, "marine science and earth science" ranked No. 2, possibly because of the high rating given to the progress in plate tectonics, volcanic disaster prevention/preparedness measures, and the like. It also has two topics in the top 20.

6.1.3. Forecasted realization times

Across all the fields covered in the survey, a clear shift in peak locations can be seen between the group of topics relating to the practical development of info-communications technology and that relating to its application, e.g. resources and energy and life science topics, highlighting the latter's dependence on the former.

6.1.4. Leading countries

The results clearly show that, due to low government funding and weak government human resources development policy in this field, the technical standard of Japan as a sea-bound country was not rated high at all. If anything, the fact that the top 20 featured no topics from "marine science and earth science" must be taken seriously.

However, practical S&T activities in "marine science and earth science" have been moving increasingly towards international cooperation projects in recent years, so that there is a view that the concept of country-to-country comparison itself is no longer relevant.

6.1.5. Effective measures government should adopt in Japan

Hopes were overwhelmingly pinned on "life science", "health, medical care and welfare", and this seems to reflect people's tendency to attach more importance to immediate gains mentioned in 6.1.2. (3). This may also reflect the heavy media coverage of topics such as O157 and malignant neoplasm during the survey period. Understandably, both human resources and equipment/facilities ranked high in "marine science and earth science", perhaps because of the perception that the private sector was almost powerless in this field. The very low expectation held for public sector research infrastructure seems to be inseparable from the fact that requests for government funding ranked second.

6.1.6. Potential problems in Japan

It is a healthy attitude that attention was paid to the natural environment, safety and morals/society as a whole. However, when focusing on "marine science and earth science", their relevance tended to be rated low, perhaps because this field is perceived as something very remote from people's daily lives.

(Takashi Hamada)

6.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 6.2-1 Forecast Topic Framework for Marine Science Field

	Sea surface	Sea-land interface	Water mass	Circulation
Marine Observation, forecasting, monitoring and surveying (elucidation of phenomena, accumulation of data, and predication/forecasting)	01 02 03	04	05 06 07 08 09 10 11	12 13 14 15 16
Protection/creation of marine environment	17	18 19 20 21 22 23 24	25	26
Resources, energy and space utilization	27 28 29	30 31 32	33 34 35 36 37 38 39	40

* Figures appearing in the table represent topic numbers.

Table 6.2-2 Forecast Topic Framework for Earth Science Field

	Atmosphere		Geosphere		
	Stratosphere	Troposphere	Atmosphere-geosphere boundary	Crust	Interior of earth
Earth Observation, forecasting, (elucidation of phenomena, accumulation of data, and predication/forecasting)	41 42	43 44		45 46 47 48 49 50 51	52
Protection/creation of global environment				53 54 55	
Natural disaster prevention/preparedness		56 57	58 59	60 61 62 63	
Common/other (marine/earth science)	64 65 66 67 68 69 70 71 72 73 74				

* Figures appearing in the table represent topic numbers.

6.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 65.2 for topics in the marine science and earth science field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Eleven topics from the marine science field and 7 topics from the earth science field featured in the top 20. Rated most important and second most important, respectively, 60. Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance and 01. Practical use of satellite-based tsunami forecasting systems both scored more than 90 points.

Table 6.3-1 Top 20 Topics in Terms of Degree of Importance Index

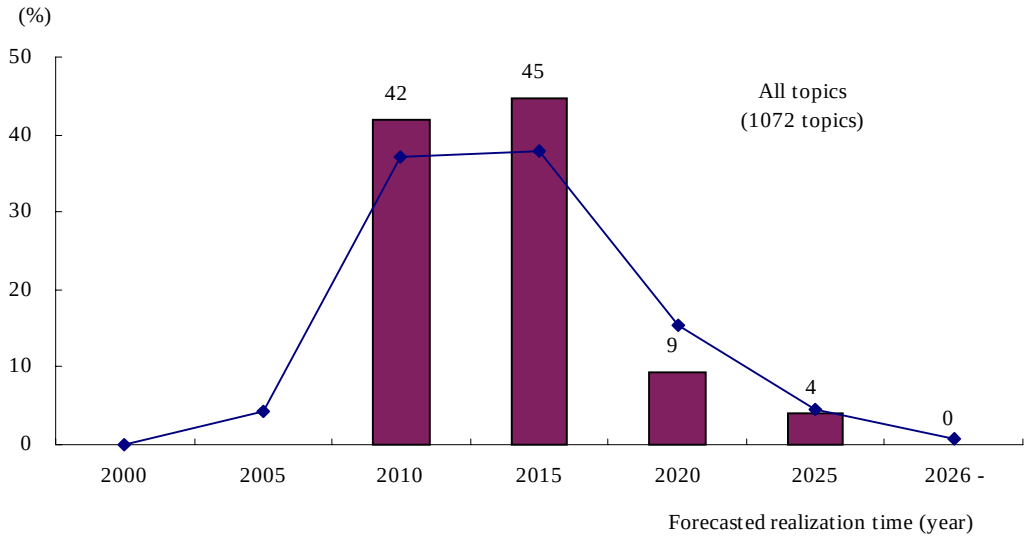
Topic	Degree of importance index	Forecasted realization time (year)
60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92	2023
01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91	2007
14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	88	2013
43 Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).	88	2014
45 Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and strain-gauges) for use in earthquake forecasting.	86	2011
58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	86	2010
12 Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	85	2011
22 Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	83	2013
17 Practical use of systems for monitoring water pollution on a global scale.	82	2012
18 Practical use of man-made off-shore islandsprocessing of living disposal. (total dissassemblyand decomposition of waste materials in order to dump harmful matter and recycle useful matter)	80	2012
26 Establishment of a quantitative marine ecosystem model, enabling elucidation of impacts on the ecosystem arising from ocean development.	80	2014
27 Widespread use of technologies for the comprehensive use and conservation of entire bays with high utilization densities, such as Tokyo Bay, Osaka Bay, etc.	80	2013
56 Development of technology to alleviate dangerously heavy rainfall through the application of nephology.	79	2020
13 Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.	79	2010
23 Development of a model for predicting the occurrence of Red Tides.	79	2009
64 Elucidation of the entire aspect of the movement and storage of carbon dioxide extending over the air, land, oceans, and sea bottoms.	79	2016
69 Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.	78	2008
42 Widespread use of international monitoring systems to detect variations of atmospheric components in the stratosphere.	77	2009
04 Practical use of satellite remote sensing technology capable of yielding precise information on water temperature, currents,. and chlorophyl concentration to 200 m depth.	76	2009
41 Elucidation of the mechanisms of formation, variation and extinction of the ozone layer surrounding the earth.	76	2009

Note 1: Degree of importance index = (number of "high" responses × 100 + number of "medium" responses × 50 + number of "low" responses × 25 + number of "unnecessary" responses × 0) ÷ total number of degree of importance responses

6.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

Fig. 6.4-1 Trends in Forecasted Realization Times

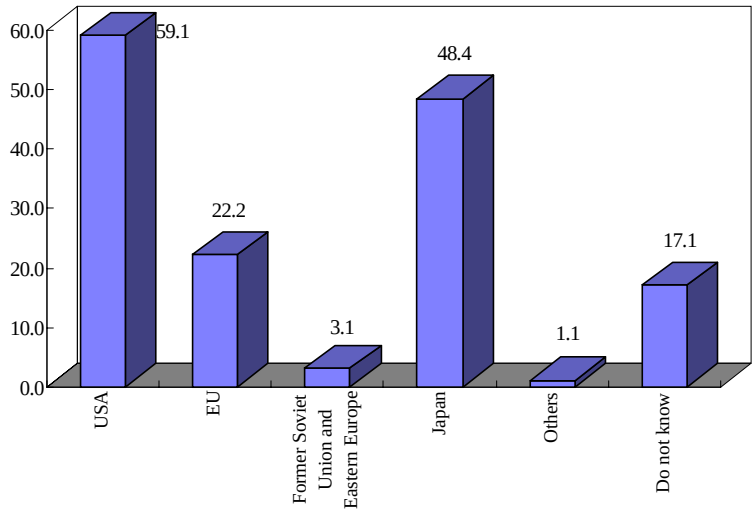


With nearly 50% of topics in this field forecasted to be realized between 2011 and 2015, the peak of the distribution of forecasted realization times was in line with that of the general trend covering all topics. Moreover, about 90% of all topics are predicted to be realized between 2006 and 2015 ó which is also very similar to the general trend.

6.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by about 60% of the respondents, the U.S. ranked No. 1 in the marine science and earth science field as a whole, followed by Japan, which was some 10 percentage points behind. The score of the third-ranking EU was less than half that of Japans, and very few respondents chose the former Soviet Union or Eastern Europe.

Fig. 6.5-1 Current Leading Countries etc. (%)



6.6. Comparison with the 5th Survey (previous survey)

Of the 74 topics included in the latest survey, 39 (53%) were identical to the previous survey, 20 (27%) were modified, and 15 (20%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 16 topics, remained the same for 1 topic and fell for 22 topics. "01: Practical use of satellite-based tsunami forecasting systems" saw the greatest jump, up 20 points, while 41. Elucidation of the mechanisms of formation, variation and extinction of the ozone layer and "63: Realization of forecasting of the outbreak and scale of pyroclastic flows (nuee ardente, etc.) accompanying volcanic eruption" saw the greatest drop, both down 15 points.

From the 4th to the 5th Survey, forecasted realization times were either pushed back or remained the same for all but one topic. Likewise, from the 5th to the 6th Survey, all but one topic "36: Development of a revolutionary new underwater navigation system which dramatically improves performance" saw their forecasted realization times pushed further into the future. The topic whose forecasted realization time was pushed back most was "60: Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance" (13 years).

Table 6.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91/2007	71/2001
02 Practical use of marine observation system using sea plane by which samples are collected, instruments are installed and retrieved.	55/2008	51/1999
04 Practical use of satellite remote sensing technology capable of yielding precise information on water temperature, currents,. and chlorophyl concentration to 200 m depth.	76/2009	73/2005
05 Practical use of automatic observation systems which are fixed in open waters and are capable of long-term (year oder) monitoring of marine phenomena and conditions from the vicinity of the sea surface down to 6,000 m depth.	70/2008	65/2003
08 Widespread use of high-technology survey vessels exclusively specializing in geological, geophysical, physical or biological research, in addition to the multi-functional survey vessels currently in vogue.	69/2009	62/2002
11 Practical use of unmanned, untethered submersibles for gathering abyssal specimens.	63/2008	62/2001
12 Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	85/2011	76/2002
13 Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.	79/2010	83/2004
14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	88/2013	82/2006
15 Development of remote sensing technology using subsea stations that monitor temperature, current direction and speed, salinity, oxygen concentration, and other parameters throughout the water column.	63/2012	60/2003
16 Practical use of systems capable of continuously monitoring environmental changes and the interaction between sea ice and seawater for an extended period of time (several months) under sea ice in the polar regions.	50/2011	50/2003
18 Practical use of man-made off-shore islands processing of living disposal. (total dissassembly and decomposition of waste materials in order to dump harmful matter and recycle useful matter)	80/2012	74/2003

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
21 Advancement in the development of sea water decontamination systems such as decontaminating concrete blocks and bio-filters, and widespread use of water affinity space creating technologies.	70/2008	71/2003
22 Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	83/2013	80/2002
25 Practical use of highly reliable automatic observation systems (chemical oceanography) located on the open sea, capable of monitoring marine pollution on a long-term basis (at least one year, without maintenance).	67/2012	73/2002
26 Establishment of a quantitative marine ecosystem model, enabling elucidation of impacts on the ecosystem arising from ocean development.	80/ 2014	83/2010
27 Widespread use of technologies for the comprehensive use and conservation of entire bays with high utilization densities, such as Tokyo Bay, Osaka Bay, etc.	80/2013	84/2004
28 Practical use of marine cities (bases for transportation, communication, research, production and recreational activities) mainly of the legged or floating structures.	60/2013	55/2007
35 Practical use of autonomous three-dimensional navigation systems for underwater vehicle	50/2009	59/2003
36 Development of a revolutionary new underwater navigation system which dramatically improves performance through twisting the body of the vessel or other innovative means.	43/2012	41/2013
37 Practical use of wireless technology for underwater communications in the horizontal plane over distances of several Km in order to facilitate smooth underwater operations.	57/2010	63/2002
39 Practical use of fuel cells that last for long period (at least one year) at abyssal depths.	59/2010	72/2003
41 Elucidation of the mechanisms of formation, variation and extinction of the ozone layer surrounding the earth.	76/2009	91/2002
45 Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and straingauges) for use in earthquake forecasting.	86/2011	82/2004
46 Widespread use of non-invasive (non-destructive) geological inspection equipment which allows the 3-D structures of strata, rocks, and fossils to be identified from meter-size CT images.	46/2012	53/2005
49 Practical use of boring technology capable of reaching the depth of 15 Km.	55/2012	62/2003
50 Development of technologies for digging into the crust at the ocean floor to gather mantle materials.	50/2016	60/2008
51 Elucidation of the series of processes including the generation, rise, storage, and extrusion of magma.	70/2016	81/2005
53 Widespread use of radar designed to be inserted into bored holes, in order to observe the behavior of water inside the earth's crust.	48/2012	61/2004
54 Practical use of analytical methods capable of tracing gradual changes (primitive fluctuations) involved in fossilization which cause material in organisms corpses to be replaced by silica.	38/2016	46/2007
57 Widespread use of observation systems for predicting downbursts (sudden downstreams) at airports and their vicinity in Japan.	68/2009	69/2000
58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	86/2010	88/2001
60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92/2023	94/2010
61 Elucidation of the correlation, if any, between animal behavior and the occurrence of earthquakes, in order to be used as earthquake prediction data.	57/2016	50/2005
62 Realization of time-series observation of the condition of magma inside volcanoes.	75/2015	77/2006

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
63 Forecasting of the outbreak and scale of pyroclastic flows (nuee ardente, etc.) accompanying volcanic eruption to be realized.	75/2015	90/2005
69 Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.	78/2008	88/2001
70 Inauguration in Japan of international research centers for comparative planetology, including the science of the earth, based on the development of planetology through specimens obtained from meteorites and planets.	52/2011	60/2001
74 Adaptation of natural history and scientific education methods to hands-on science museums capable of developing scientific skills in an enjoyable and playful atmosphere, and their spread throughout Japan.	63/2010	53/2001

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Marine observation, forecasting, monitoring and surveying (elucidation of phenomena, accumulation of data, and predication/forecasting)	1	Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	1	208	13	38	49	88	77	20	3	0	13	26	86	4		2	8	68	17	1	62	0	12	56	31	28	2	64	2	1	8	25	3	3
			2	179	15	39	46	91	81	19	0	0	5	26	89	1		2	7	73	8	1	68	0	7	69	28	18	0	72	0	0	6	25	1	1
			X	27	100	0	0	98	96	4	0	0	11	33	89	4		4	7	78	15	0	78	0	4	89	44	4	0	78	0	0	11	26	4	0
	2	Practical use of marine observation system using sea plane by which samples are collected, instruments are installed and retrieved.	1	209	19	33	47	56	25	50	23	2	7	88	10	26		9	7	61	13	1	14	2	30	30	33	24	1	63	8	2	22	10	1	3
			2	179	16	32	52	55	21	60	17	2	4	88	6	25		6	4	66	11	0	11	2	24	29	40	22	0	74	6	0	26	7	1	2
			X	28	100	0	0	68	39	54	7	0	7	96	0	36		7	4	71	11	0	18	4	21	32	36	21	0	79	14	0	18	0	0	0
	3	Development of methods for accurately calculating the amount of heat transfer in the water cycle of evaporation, cloud formation and rainfall over the oceans.	1	165	10	30	60	70	43	52	4	1	9	96	25	32		2	7	81	27	1	36	0	15	70	27	23	6	63	1	0	19	8	1	1
			2	142	9	28	63	69	39	59	1	0	6	97	20	27		1	5	82	24	0	37	0	11	75	25	18	2	68	0	0	21	5	0	1
			X	13	100	0	0	88	77	23	0	0	15	100	15	38		0	0	100	38	0	54	0	0	85	23	8	0	92	0	0	23	0	0	0
	4	Practical use of satellite remote sensing technology capable of yielding precise information on water temperature, currents,. and chlorophyl concentration to 200 m depth.	1	225	26	32	43	74	51	42	6	0	13	96	13	31		12	10	84	30	3	27	1	9	59	41	30	7	61	1	0	19	4	1	2
			2	190	23	30	47	76	54	44	2	1	12	93	9	25		8	7	88	30	2	27	1	7	68	44	26	1	67	0	1	18	2	0	2
			X	43	100	0	0	88	79	19	0	2	19	93	9	35		12	0	93	47	0	42	2	2	70	44	14	2	77	0	2	16	0	0	5
	5	Practical use of automatic observation systems which are fixed in open waters and are capable of long-term (year oder) monitoring of marine phenomena and conditions from the vicinity of the sea surface down to 6,000 m depth.	1	230	27	31	42	69	44	43	12	0	10	92	13	41		2	6	77	20	1	30	1	16	44	41	27	3	76	2	0	20	7	0	3
			2	185	25	34	41	70	44	50	7	0	9	94	7	35		1	3	84	21	1	33	1	11	51	44	23	1	78	1	0	21	3	0	3
			X	46	100	0	0	85	70	30	0	0	11	96	11	39		2	0	96	26	0	43	2	0	46	52	15	2	85	2	0	17	7	0	7
	6	Practical use of 3-D image analysis systems capable of identifying minute oceanic life (microorganisms, plankton, etc.)	1	176	19	28	52	60	31	50	17	2	15	86	6	40		1	9	65	26	0	30	1	23	57	48	24	10	48	0	1	18	1	1	2
			2	145	17	26	57	59	26	60	13	1	12	88	6	38		1	4	77	23	1	32	0	14	64	54	22	8	52	0	0	17	1	0	1
			X	24	100	0	0	77	54	46	0	0	13	83	8	54		4	0	92	46	0	42	0	0	75	67	8	8	63	0	0	8	0	0	4
	7	Development of sensors capable of accurately identifying objects under water at distances of several hundred meters.	1	160	8	31	61	52	21	48	29	2	39	46	24	25		1	11	72	20	9	28	0	19	43	51	19	1	53	1	1	16	14	1	2
			2	140	4	35	61	53	18	59	22	1	38	49	17	24		1	10	79	19	6	31	1	15	41	60	18	1	55	0	1	14	12	1	1
			X	6	100	0	0	79	67	17	17	0	17	67	17	17		0	0	83	33	0	67	0	17	33	67	17	0	50	0	0	17	0	17	17
	8	Widespread use of high-technology survey vessels exclusively specializing in geological, geophysical, physical or biological research, in addition to the multi-functional survey vessels currently in vogue.	1	251	31	29	39	66	41	42	15	2	17	88	10	48		10	12	75	34	9	25	1	12	42	34	29	2	65	3	4	16	4	1	4
			2	205	28	32	40	69	43	47	10	1	12	86	5	43		10	9	83	34	4	29	0	8	46	37	25	1	72	1	5	16	4	0	4
			X	57	100	0	0	78	63	26	9	2	18	93	7	56		16	7	77	30	2	25	0	11	46	32	25	0	74	2	14	16	4	0	9
	9	Widespread use of ocean observation systems employing continuous acoustic tomography.	1	178	13	30	57	59	28	53	19	0	15	86	14	40		3	8	78	20	4	33	1	16	53	46	24	2	63	0	0	21	8	1	2
			2	152	12	30	58	60	26	63	11	0	14	84	9	39		2	5	84	17	3	38	1	11	55	43	22	1	67	0	0	22	6	0	2
			X	18	100	0	0	79	65	24	12	0	17	78	11	56		6	0	100	39	0	56	6	0	39	39	11	0	83	0	0	33	11	0	6
	10	Development of maintenance-free devices capable of selectively monitoring subjects according to sudden and dramatic environmental changes on the ocean floor.	1	122	8	32	60	62	34	49	16	2	15	84	26	34		7	15	57	17	3	25	1	28	51	42	23	1	60	0	2	23	6	0	1
			2	111	5	25	69	59	26	60	12	2	9	79	16	37		8	11	62	15	1	29	0	25	53	39	17	0	67	0	2	26	3	0	2
			X	6	100	0	0	88	83	0	17	0	33	83	17	50		0	17	50	50	0	17	0	33	33	50	17	0	50	0	17	50	0	0	17

(Note) See page 7 for the interpretation of the graphs.

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					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Marine observation, forecasting, monitoring and surveying (elucidation of phenomena, accumulation of data, and prediction/forecasting)	11	Practical use of unmanned, untethered submersibles for gathering abyssal specimens.	1	205	11	33	57	62	34	48	17	1	29	82	8	39		1	6	76	40	4	62	1	9	38	55	27	0	73	1	0	21	8	0	1
			2	174	10	32	58	63	31	61	8	0	22	78	4	47		1	5	79	36	3	68	0	7	35	59	24	0	76	0	1	23	4	1	2
			X	18	100	0	0	82	67	28	6	0	11	78	11	44		6	0	89	33	6	61	0	0	22	61	17	0	83	0	0	17	0	6	11
	12	Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	1	215	21	26	53	80	62	35	3	0	26	87	35	25		3	6	50	13	2	65	0	15	70	26	25	9	60	0	1	20	9	1	3
			2	185	21	29	50	85	69	31	0	0	27	86	30	22		2	3	58	10	1	76	0	9	76	21	21	5	69	0	1	20	6	0	2
			X	39	100	0	0	95	90	10	0	0	26	87	38	41		0	0	77	18	0	90	0	0	85	23	23	8	77	0	0	23	8	0	0
	13	Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.	1	220	12	35	53	78	58	38	4	0	15	95	25	35		4	8	86	35	3	46	1	10	74	30	23	8	65	0	0	18	6	3	1
			2	183	10	38	52	79	61	36	4	0	12	94	14	38		2	7	88	31	2	51	1	7	79	25	23	4	67	0	1	19	5	2	2
			X	19	100	0	0	93	89	5	5	0	16	89	32	63		0	5	95	53	0	63	11	0	58	16	26	0	84	0	5	16	5	0	0
	14	Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	1	178	18	32	50	83	66	31	2	0	34	92	17	26		3	10	54	26	3	47	2	24	73	38	20	12	55	0	1	21	4	4	2
			2	149	15	30	55	88	77	22	1	0	37	89	13	24		3	8	68	24	1	58	1	17	80	36	15	8	62	0	1	21	3	4	2
			X	22	100	0	0	98	95	5	0	0	50	91	14	50		0	5	86	41	0	64	5	0	68	50	14	9	68	0	5	27	5	5	0
	15	Development of remote sensing technology using subsea stations that monitor temperature, current direction and speed, salinity, oxygen concentration, and other parameters throughout the water column.	1	206	16	39	45	64	36	50	13	1	15	94	14	34		4	9	67	18	3	33	0	22	49	47	24	2	69	2	1	21	7	1	2
			2	179	12	41	47	63	32	58	9	1	12	93	9	36		2	7	74	13	2	39	0	17	55	44	18	1	72	0	2	23	6	1	2
			X	21	100	0	0	86	71	29	0	0	14	90	10	52		0	0	86	14	0	57	0	5	57	52	5	0	76	0	5	48	5	5	5
	16	Practical use of systems capable of continuously monitoring environmental changes and the interaction between sea ice and seawater for an extended period of time (several months) under sea ice in the polar regions.	1	167	12	31	57	49	15	53	30	2	10	89	2	39		2	8	77	27	24	22	7	11	51	41	19	2	63	0	1	23	5	1	1
			2	147	12	29	59	50	15	54	30	1	7	88	1	39		1	6	85	26	24	23	6	10	57	37	16	2	69	0	2	24	3	0	2
			X	18	100	0	0	68	39	56	6	0	11	83	0	72		6	0	94	44	22	28	11	0	61	44	6	0	83	0	6	39	0	0	6
Protection/creation of marine environment	17	Practical use of systems for monitoring water pollution on a global scale.	1	222	18	28	53	78	60	34	6	0	21	97	28	18		3	9	72	40	2	38	1	18	55	36	27	11	69	3	1	18	6	4	1
			2	193	18	26	55	82	65	32	3	0	19	96	24	11		3	8	83	38	1	39	1	15	64	36	20	5	77	2	1	17	4	3	2
			X	35	100	0	0	93	86	14	0	0	17	91	29	20		0	11	91	69	0	57	0	9	63	49	14	6	77	3	3	29	9	3	3
	18	Practical use of man-made off-shore islands processing of living disposal. (total dissassembly and decomposition of waste materials in order to dump harmful matter and recycle useful matter)	1	166	17	31	52	73	58	25	11	6	51	67	39	2		12	6	20	16	1	46	0	33	27	48	18	2	55	25	3	62	13	4	1
			2	150	17	31	52	80	68	21	7	4	57	67	37	2		7	7	18	12	0	62	0	24	21	57	10	1	63	25	3	65	9	3	2
			X	26	100	0	0	87	81	12	0	8	73	62	31	0		12	0	19	8	0	88	0	12	15	65	8	0	62	27	12	73	15	0	4
	19	Practical use of systems capable of monitoring changes in living resources on coastal ocean floors over an extended period of time.	1	163	15	36	50	72	49	40	11	0	31	87	14	20		11	12	45	18	1	37	1	33	52	44	22	9	64	2	0	21	6	4	1
			2	140	12	36	51	74	51	43	6	0	36	81	14	15		9	11	51	19	1	45	0	32	59	46	16	4	71	3	0	24	4	2	1
			X	17	100	0	0	85	71	29	0	0	47	76	24	24		18	12	65	47	0	47	0	24	41	59	12	6	65	6	0	41	6	0	0
	20	Initiation of long-term, comprehensive observation on an international basis, and elucidation of the formation mechanism of carbon dioxide fixing coral reefs.	1	190	12	28	59	58	31	44	22	3	9	93	6	32		5	7	59	26	1	47	9	19	67	31	18	8	56	2	3	27	5	3	1
			2	153	10	25	65	57	24	58	16	3	3	92	2	32		5	7	60	22	1	48	8	20	75	30	11	4	63	2	1	28	5	1	0
			X	15	100	0	0	62	40	40	7	13	7	93	7	33		20	0	67	33	0	47	27	7	53	33	20	7	53	0	7	27	7	0	0

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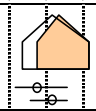
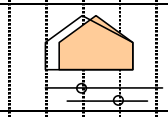
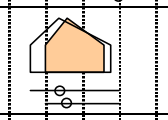
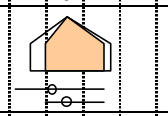
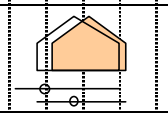
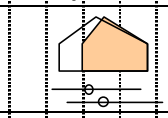
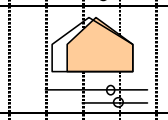
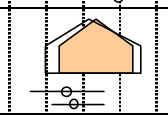
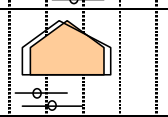
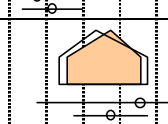
Protection/creation of marine environment	21	Advancement in the development of sea water decontamination systems such as decontaminating concrete blocks and bio-filters, and widespread use of water affinity space creating technologies.	1	140	16	34	50	70	46	43	11	1	46	76	50	4		4	9	31	23	1	59	1	24	39	61	20	5	57	17	4	46	4	4	1
			2	123	11	36	54	70	45	46	7	2	41	72	60	2		2	4	33	26	0	70	0	18	41	70	9	3	62	14	2	54	5	2	1
			X	13	100	0	0	85	69	31	0	0	62	69	62	0		0	8	46	23	0	85	0	8	38	77	8	0	77	8	15	54	15	0	8
	22	Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	1	170	18	31	52	79	62	32	6	1	42	79	41	6		7	13	18	11	0	55	1	32	35	56	16	3	58	14	4	41	4	4	1
			2	143	15	32	53	83	69	25	6	0	38	76	42	3		7	5	18	10	0	66	1	26	34	65	8	1	68	14	2	51	3	2	2
			X	21	100	0	0	90	81	19	0	0	43	90	52	0		0	5	48	24	0	81	5	10	43	57	10	0	71	14	10	57	5	5	10
	23	Development of a model for predicting the occurrence of Red Tides.	1	181	22	28	51	74	53	38	8	1	28	80	36	13		4	9	23	12	1	79	1	13	70	33	23	17	54	3	2	22	2	4	1
			2	144	18	34	48	79	62	31	7	0	28	82	40	8		3	5	24	6	0	86	0	8	78	30	15	12	63	2	0	26	2	2	1
			X	26	100	0	0	89	81	15	4	0	31	88	31	15		0	8	42	12	0	92	0	4	81	46	12	19	65	4	0	35	4	4	0
	24	Widespread use of breakwaters which take into account the natural scenery along with the proliferation of microorganisms living in the ocean.	1	155	24	28	48	59	30	47	21	1	41	63	53	4		6	7	22	15	0	55	1	32	41	54	17	3	52	15	2	35	5	5	0
			2	137	19	28	53	60	30	53	16	1	34	60	58	2		4	4	21	15	0	61	1	24	36	69	9	0	61	14	1	41	4	1	1
			X	26	100	0	0	75	56	32	12	0	42	58	62	0		4	4	31	23	0	92	0	0	46	77	4	0	65	23	0	35	4	0	4
	25	Practical use of highly reliable automatic observation systems (chemical oceanography) located on the open sea, capable of monitoring marine pollution on a long-term basis (at least one year, without maintenance).	1	198	14	34	52	66	38	49	12	1	15	91	16	23		2	9	61	20	0	35	2	23	45	55	21	5	65	3	3	18	4	1	1
			2	167	17	32	51	67	38	55	6	1	11	92	8	22		1	7	71	17	1	41	1	19	46	64	14	1	74	1	1	19	3	1	2
			X	28	100	0	0	79	61	36	4	0	7	93	0	36		4	7	79	36	0	43	4	11	46	79	14	0	79	0	4	18	0	0	4
	26	Establishment of a quantitative marine ecosystem model, enabling elucidation of impacts on the ecosystem arising from ocean development.	1	183	25	35	40	77	57	36	6	1	29	90	17	30		10	11	69	34	1	44	1	15	72	43	19	13	59	1	2	21	1	5	1
			2	152	24	35	41	80	62	34	3	1	30	91	16	27		10	8	78	38	0	49	1	11	80	47	13	8	67	0	1	22	1	3	1
			X	36	100	0	0	88	78	17	6	0	44	92	17	33		6	14	89	56	0	58	0	3	78	50	22	6	72	0	3	28	0	0	3
Resources energy and space utilization	27	Widespread use of technologies for the comprehensive use and conservation of entire bays with high utilization densities, such as Tokyo Bay, Osaka Bay, etc.	1	179	27	30	43	79	61	33	6	1	69	60	51	6		6	12	27	15	0	58	0	20	36	61	12	8	50	27	3	38	10	7	2
			2	158	26	30	44	80	63	31	5	1	76	54	52	3		5	8	27	13	0	71	0	15	35	61	11	6	58	25	3	49	8	3	1
			X	41	100	0	0	92	85	12	2	0	78	54	51	2		10	5	37	20	0	80	0	10	44	59	10	10	61	29	5	63	17	0	5
	28	Practical use of marine cities (bases for transportation, communication, research, production and recreational activities) mainly of the legged or floating structures.	1	151	32	17	51	58	33	40	22	6	85	30	40	5		9	9	31	21	0	58	0	22	20	56	17	1	53	32	2	60	23	8	1
			2	133	33	17	50	60	33	43	21	3	87	24	43	3		5	7	34	20	0	74	0	14	20	62	10	2	62	32	2	65	23	2	2
			X	44	100	0	0	75	57	34	5	5	93	32	50	5		7	2	32	20	0	91	0	0	18	70	9	2	75	41	0	64	32	2	2
	29	Practical use of on-site inspection, diagnosis, and maintenance technology for marine facilities.	1	117	23	29	48	63	33	54	12	1	70	29	34	4		1	5	44	33	3	43	0	25	30	61	19	3	47	15	0	23	16	3	1
			2	109	24	27	50	63	30	61	9	0	79	25	27	2		1	2	54	37	1	55	0	20	29	69	13	1	55	14	0	24	11	0	1
			X	26	100	0	0	75	54	38	8	0	77	23	31	0		0	0	69	54	0	69	0	0	42	65	12	0	69	15	0	27	27	0	0
	30	Widespread use of marine ranches with optimal environmental management through incorporation of biological system technology and a wide range of engineering technology.	1	170	15	31	55	64	37	47	13	3	55	74	24	4		13	6	18	15	0	64	1	25	39	66	18	4	54	12	2	52	6	6	0
			2	141	16	28	57	66	38	50	9	2	60	72	20	3		11	2	18	11	1	76	0	19	37	77	11	2	65	10	1	62	5	4	1
			X	22	100	0	0	82	64	36	0	0	86	77	9	5		9	5	32	23	5	86	0	5	68	91	14	0	77	0	5	64	9	0	0

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Resources energy and space utilization	31	Development of revolutionary drag-reducing technology for underwater/surface vessel , such as the use of active skin to cover the surface of the hull.	1	72	19	32	49	54	22	54	19	4	72	26	11	17		3	10	42	19	7	56	0	22	42	57	18	0	47	0	0	15	8	1	3
			2	66	14	32	55	54	18	64	17	2	80	26	11	11		5	9	52	18	6	67	0	12	42	55	17	0	55	0	0	18	6	0	2
			X	9	100	0	0	53	11	78	11	0	78	33	0	11		11	22	56	33	0	78	0	0	33	67	11	0	56	0	0	22	0	0	0
	32	Practical use of breakwaters capable of utilizing the wave energy to generate electricity.	1	165	20	24	56	65	39	43	17	1	52	79	17	2		3	5	21	34	1	70	1	15	27	58	19	0	61	15	2	33	12	2	2
			2	148	19	26	55	65	36	51	13	0	59	74	15	1		3	5	19	31	0	76	2	11	22	68	13	0	68	15	1	41	9	1	1
			X	28	100	0	0	68	42	46	12	0	32	71	21	4		4	0	7	32	0	82	4	0	7	46	7	0	54	25	7	32	4	0	4
	33	Widespread use of culture technology allowing engineering applications microbes extracted from sea water or the sea bottom.	1	112	12	21	67	59	29	51	18	2	52	67	14	21		1	12	54	31	1	50	0	26	56	47	21	20	48	1	3	38	12	7	1
			2	93	6	25	69	55	22	59	17	2	61	62	9	16		2	11	66	31	0	65	0	19	66	45	19	16	54	1	1	42	9	4	0
			X	6	100	0	0	75	50	50	0	0	50	100	0	0		0	0	100	33	0	100	0	0	67	67	17	17	50	0	0	33	0	0	0
	34	Development of sea-water (hydrogen) engines to power underwater vehicle.	1	55	7	25	67	58	34	40	19	8	55	55	7	16		4	13	38	16	5	40	0	29	42	51	16	0	60	2	0	20	13	4	5
			2	52	8	21	71	59	31	47	16	6	67	44	2	17		6	8	40	15	4	44	0	33	42	56	13	2	62	4	0	25	12	4	2
			X	4	100	0	0	56	25	50	25	0	100	25	0	25		0	0	25	25	25	75	0	0	25	50	0	25	50	0	0	50	25	0	0
	35	Practical use of autonomous three-dimensional navigation systems for underwater vehicle.	1	79	14	25	61	53	22	50	24	4	70	33	6	25		0	3	66	23	8	52	0	15	38	54	15	1	58	3	0	9	16	3	1
			2	70	13	26	61	50	13	61	26	0	79	23	1	20		1	3	74	24	4	57	0	11	41	61	14	0	67	1	0	4	19	1	1
			X	9	100	0	0	53	11	78	11	0	78	44	0	11		0	0	78	11	0	89	0	0	44	67	0	0	56	0	0	0	22	0	0
	36	Development of a revolutionary new underwater navigation system which dramatically improves performance through twisting the body of the vessel or other innovative means.	1	61	13	33	54	44	14	42	35	9	64	23	3	34		16	26	33	10	3	36	0	34	54	41	8	0	43	0	0	5	11	2	5
			2	60	10	32	58	43	12	47	33	8	65	15	0	28		15	20	32	8	2	48	0	32	62	42	3	0	55	0	0	3	13	2	2
			X	6	100	0	0	46	17	33	50	0	83	33	0	17		17	0	50	0	0	100	0	0	67	33	0	0	50	0	0	0	33	0	0
	37	Practical use of wireless technology for underwater communications in the horizontal plane over distances of several km in order to facilitate smooth underwater operations.	1	71	8	17	75	60	31	49	19	1	76	28	15	15		3	6	69	25	8	34	0	21	51	52	21	0	49	0	0	10	17	0	1
			2	63	6	17	76	57	24	57	17	2	78	24	8	14		2	6	71	29	5	35	0	22	60	56	13	0	60	0	0	8	14	2	3
			X	4	100	0	0	75	50	50	0	0	75	25	0	0		0	0	100	75	0	100	0	0	25	50	0	0	100	0	0	0	25	0	0
	38	Practical use of robots for underwater resource exploration at depths of up to 10,000 m.	1	142	8	20	72	53	20	54	25	2	46	74	5	25		3	9	63	35	4	62	0	11	35	51	29	1	62	0	1	17	8	1	3
			2	129	8	18	74	52	14	67	19	1	44	76	0	26		2	5	73	31	2	70	0	9	43	60	23	0	75	1	0	21	4	2	2
			X	10	100	0	0	53	10	80	10	0	30	80	0	0		10	0	60	20	10	90	0	0	40	40	0	0	60	0	0	30	0	0	0
	39	Practical use of fuel cells that last for long period (at least one year) at abyssal depths.	1	95	4	17	79	62	34	46	20	0	47	65	11	25		3	11	57	27	3	39	1	25	39	53	18	0	62	4	3	22	9	4	1
			2	81	2	16	81	59	26	59	15	0	49	69	4	22		1	6	68	20	0	49	0	21	37	62	12	0	70	1	2	27	4	2	1
			X	2	100	0	0	75	50	50	0	0	50	100	0	0		0	0	50	50	0	100	0	0	100	50	0	0	100	0	0	50	0	0	0
	40	Widespread use of micro-biotelemetry to analyze the migratory activities of marine organisms over extended periods of time.	1	123	6	25	69	58	28	48	23	1	17	73	4	59		1	8	67	27	2	53	3	19	47	59	15	3	61	2	0	19	4	7	2
			2	104	5	21	74	55	20	59	19	1	15	73	5	59		1	3	72	20	0	59	2	17	50	68	12	0	69	1	0	18	2	2	2
			X	5	100	0	0	65	40	40	20	0	20	80	0	80		0	20	80	20	0	100	0	0	80	80	0	0	80	0	0	20	0	0	0

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Earth observation and forecasting (elucidation of phenomena, accumulation of data, and predication/forecasting)	41	Elucidation of the mechanisms of formation, variation and extinction of the ozone layer surrounding the earth.	1	142	4	18	77	75	52	43	4	1	9	95	21	28		4	11	80	43	4	39	1	15	75	23	32	9	65	1	1	23	3	4	0
			2	124	6	17	77	76	54	42	4	0	7	94	14	22		2	8	82	44	2	41	1	12	78	22	31	6	68	0	1	29	1	2	0
			X	7	100	0	0	86	71	29	0	0	14	100	14	57		0	0	100	71	0	57	0	0	86	29	71	0	71	0	0	43	0	0	0
	42	Widespread use of international monitoring systems to detect variations of atmospheric components in the stratosphere.	1	113	4	19	76	71	48	40	11	1	11	93	11	22		3	10	78	43	3	38	1	13	58	25	25	10	68	3	2	19	6	1	0
			2	98	4	17	79	77	56	40	4	0	7	91	3	17		2	8	82	48	0	42	1	10	62	26	18	7	69	3	1	27	4	1	0
			X	4	100	0	0	75	50	50	0	0	0	100	0	50		0	0	100	50	0	50	0	0	50	25	75	25	50	0	0	25	0	0	0
	43	Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).	1	123	7	24	68	82	66	30	3	0	36	83	43	21		10	11	80	48	3	63	2	11	69	21	30	14	53	1	0	15	9	8	1
			2	114	6	24	70	88	77	21	3	0	34	85	42	15		10	5	83	46	0	66	1	10	74	18	32	7	59	1	0	18	5	6	1
			X	7	100	0	0	100	100	0	0	0	29	86	71	29		0	0	100	71	0	86	0	0	71	14	57	14	100	0	0	14	0	0	0
	44	Practical use of unmanned planes for typhoon observation and data/sample collection.	1	85	5	19	76	62	33	49	16	1	20	69	45	18		7	9	62	12	5	22	4	22	36	38	27	1	66	8	1	13	16	0	2
			2	82	4	18	78	63	32	60	7	1	20	78	41	15		6	9	70	9	0	24	2	18	44	33	23	0	73	2	1	13	21	0	2
			X	3	100	0	0	83	67	33	0	0	0	67	33	0		0	0	100	33	0	33	0	0	33	67	0	0	100	0	0	33	33	0	0
	45	Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and strain-gauges) for use in earthquake forecasting.	1	109	12	24	64	82	67	25	8	0	16	35	77	27		6	9	44	8	2	80	1	6	48	32	30	5	71	4	4	9	10	2	1
			2	98	11	19	69	86	77	16	7	0	12	34	79	24		4	8	40	4	1	85	0	6	51	31	28	2	77	4	1	9	12	2	1
			X	11	100	0	0	82	73	9	18	0	9	27	91	36		0	0	36	0	0	100	0	0	64	27	27	0	91	0	9	9	0	0	0
	46	Widespread use of non-invasive (non-destructive) geological inspection equipment which allows the 3-D structures of strata, rocks, and fossils to be identified from meter-size CT images.	1	68	13	29	57	45	15	40	40	4	18	41	24	57		1	12	49	19	0	47	0	29	41	41	37	6	44	0	1	13	9	4	0
			2	59	14	24	63	46	16	41	38	5	15	39	19	63		2	8	51	17	0	49	0	29	47	34	36	3	58	0	2	14	5	0	0
			X	8	100	0	0	41	13	38	38	13	0	50	13	75		0	0	63	25	0	50	0	13	75	25	38	13	75	0	0	25	13	0	0
	47	Practical use of super-conducting gravity meters with the capability to detect the movement of material deep inside the earth.	1	47	13	19	68	45	11	52	32	5	6	55	17	62		2	23	53	19	0	38	2	28	51	17	30	6	51	0	0	19	9	4	0
			2	43	14	14	72	43	10	48	40	2	5	56	12	63		5	12	60	16	0	42	2	21	56	12	30	5	65	0	0	23	5	0	0
			X	6	100	0	0	50	33	17	33	17	0	50	17	67		17	0	67	50	0	50	0	0	50	0	17	0	83	0	0	33	17	0	0
	48	Practical use of 6,000 meter-class deep sea excavation technology capable of measuring stresses in the crust of the ocean floor.	1	95	20	26	54	59	29	50	20	1	19	64	31	48		1	4	82	27	13	38	0	9	45	43	26	1	69	1	0	22	5	2	1
			2	82	17	29	54	58	26	56	18	0	15	70	24	52		0	4	87	26	7	40	0	6	46	43	24	0	76	0	0	23	1	1	1
			X	14	100	0	0	71	50	36	14	0	0	86	29	50		0	7	93	36	7	43	0	7	43	50	14	0	79	0	0	29	7	0	0
	49	Practical use of boring technology capable of reaching the depth of 15 km.	1	89	16	27	57	54	25	45	25	5	19	72	25	49		4	10	69	37	49	22	0	7	43	51	22	1	64	0	2	27	8	0	0
			2	77	17	26	57	55	25	45	29	1	16	71	22	51		4	9	77	34	55	21	0	3	38	57	16	0	77	0	0	26	4	0	0
			X	13	100	0	0	63	38	46	8	8	8	85	38	62		8	15	85	69	85	38	0	0	31	77	15	0	85	0	0	31	15	0	0
	50	Development of technologies for digging into the crust at the ocean floor to gather mantle materials.	1	82	16	30	54	51	21	43	32	4	13	56	16	59		7	16	73	29	27	21	0	17	37	46	29	2	68	1	1	33	10	0	0
			2	71	15	30	55	50	19	46	33	3	8	58	11	63		4	6	79	27	32	20	0	14	35	46	24	0	82	0	1	31	7	0	1
			X	11	100	0	0	61	36	45	9	9	0	55	9	82		18	18	82	18	27	27	0	9	18	45	27	0	82	0	9	27	9	0	0

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Earth observation and forecasting	51	Elucidation of the series of processes including the generation, rise, storage, and extrusion of magma.	1	81	10	27	63	70	47	41	10	3	9	54	65	47		6	12	63	23	7	78	1	9	75	21	25	4	51	1	0	17	6	4	0
			2	68	7	28	65	70	47	41	11	2	7	57	59	56		3	10	68	15	7	81	0	4	82	18	21	3	59	0	0	16	3	3	1
			X	5	100	0	0	75	60	20	20	0	0	100	60	60		20	20	100	20	0	100	0	0	100	20	60	20	60	0	0	20	20	0	0
	52	Positioning in several locations, under an international agreement, of neutrino detectors for the purpose of surveying the earth's internal structure.	1	51	0	14	86	42	13	38	42	8	2	41	8	67		6	18	57	31	6	73	0	16	47	18	31	0	71	0	0	14	2	2	0
			2	43	0	12	88	37	7	34	49	10	5	44	5	70		5	14	60	28	7	84	0	7	44	26	30	0	79	0	0	14	0	0	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Protection/creation of global environment	53	Widespread use of radar designed to be inserted into bored holes, in order to observe the behavior of water inside the earth's crust.	1	48	13	17	71	50	19	49	26	6	17	67	38	27		6	10	46	17	4	50	0	25	44	40	25	6	44	0	0	15	8	0	0
			2	36	14	22	64	48	14	53	31	3	17	58	39	33		3	11	56	19	3	56	0	25	50	47	22	0	53	0	0	22	3	0	0
			X	5	100	0	0	75	60	20	20	0	20	80	40	0		20	0	80	60	0	60	0	20	40	40	40	0	20	0	0	0	0	0	0
	54	Practical use of analytical methods capable of tracing gradual changes (primitive fluctuations) involved in fossilization which cause material in organisms corpses to be replaced by silica.	1	53	6	30	64	38	10	31	51	8	9	51	0	60		8	28	42	32	4	28	0	40	64	19	25	9	30	0	2	15	2	6	0
			2	45	7	22	71	38	14	16	66	5	11	44	0	69		7	16	53	29	7	24	0	38	82	18	31	4	36	0	0	22	0	2	0
			X	3	100	0	0	33	0	33	67	0	67	67	0	33		0	0	100	67	33	100	0	0	100	67	67	0	33	0	0	67	0	0	0
	55	Widespread use of systems for forcing water into high-temperature subterranean locations in order to extract thermal energy in the form of steam.	1	101	6	25	69	69	46	41	11	2	37	81	13	9		3	13	44	26	4	65	6	20	31	50	18	1	54	10	1	52	13	2	1
			2	86	5	21	74	65	36	52	11	1	41	73	12	2		3	9	45	29	2	67	2	19	31	56	12	1	67	10	0	57	8	1	1
			X	4	100	0	0	100	100	0	0	0	50	100	0	25		0	0	50	50	0	75	0	0	0	75	25	0	75	50	0	50	0	0	0
Natural disaster prevention/preparedness	56	Development of technology to alleviate dangerously heavy rainfall through the application of nephology.	1	86	8	13	79	76	58	33	8	3	19	50	69	14		13	26	42	13	6	28	1	34	51	21	17	2	36	1	1	34	20	1	0
			2	85	8	9	82	79	63	30	6	1	15	44	73	6		11	24	51	7	6	29	1	31	65	24	15	0	48	2	0	44	14	0	0
			X	7	100	0	0	100	100	0	0	0	29	57	57	0		14	14	71	14	29	43	0	0	57	57	14	0	29	14	0	43	29	0	0
	57	Widespread use of observation systems for predicting downbursts (sudden downstreams) at airports and their vicinity in Japan.	1	87	8	11	80	67	41	46	11	2	25	15	78	8		3	10	72	11	1	37	1	13	55	31	20	3	49	2	1	14	15	1	0
			2	83	7	14	78	68	41	49	7	2	29	12	73	5		2	10	75	8	0	42	0	11	64	34	14	1	58	6	0	12	14	0	0
			X	6	100	0	0	83	67	33	0	0	33	17	83	0		0	33	100	17	0	33	0	0	50	33	17	0	67	33	0	0	17	0	0
	58	Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	1	100	13	13	74	78	60	33	5	1	15	20	89	3		6	12	16	6	1	66	0	22	57	35	22	8	61	0	0	16	12	2	0
			2	88	13	16	72	86	75	22	2	1	14	19	88	1		6	9	15	2	0	75	1	17	59	32	19	3	69	0	0	15	8	2	0
			X	11	100	0	0	95	90	10	0	0	0	36	82	0		18	0	9	9	0	64	0	18	73	45	18	0	73	0	0	9	0	0	0
	59	Development of technology for monitoring chronological trends in the location and amount of snowfall, facilitating forecasting of the scale and degree of risk of surface avalanches in certain locations in Japan.	1	85	9	16	74	64	36	49	14	1	13	12	85	6		2	8	16	21	0	51	1	28	51	29	22	6	56	0	0	13	16	2	0
			2	82	11	11	78	64	32	60	9	0	11	10	89	2		1	7	12	18	0	56	0	29	59	28	18	4	65	0	1	7	17	2	1
			X	9	100	0	0	78	56	44	0	0	11	22	89	0		0	0	22	56	0	78	0	11	56	44	11	0	56	0	0	0	11	0	0
	60	Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	1	115	9	24	67	90	85	11	2	3	17	21	85	22		27	16	34	14	3	75	8	10	58	23	34	7	54	3	3	7	16	6	1
			2	102	9	21	71	92	87	9	2	2	15	21	85	19		29	14	31	9	3	78	8	8	59	25	32	5	59	4	1	5	19	3	1
			X	9	100	0	0	100	100	0	0	0	33	33	89	33		22	0	11	11	0	89	0	0	78	33	44	11	44	0	0	0	11	0	0

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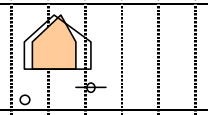
Natural disaster prevention/preparedness	61	Elucidation of the correlation, if any, between animal behavior and the occurrence of earthquakes, in order to be used as earthquake prediction data.	1	89	6	15	80	59	30	47	19	3	6	19	79	31		13	31	11	7	6	38	25	29	51	24	16	13	34	0	3	9	13	6	1
			2	86	7	14	79	57	27	51	20	2	5	16	81	24		15	26	9	2	2	48	23	26	62	21	10	10	30	1	1	8	16	5	1
			X	6	100	0	0	80	60	40	0	0	0	17	67	17		0	0	33	17	0	67	0	17	67	50	0	0	67	0	0	0	33	0	0
	62	Realization of time-series observation of the condition of magma inside volcanoes.	1	73	11	15	74	72	48	45	5	1	5	48	77	33		7	18	52	10	3	74	3	11	66	29	29	4	67	0	0	15	11	1	0
			2	63	13	17	70	75	52	44	5	0	3	48	78	27		5	14	59	11	0	78	0	8	67	24	27	5	71	0	0	13	8	0	0
			X	8	100	0	0	86	71	29	0	0	13	75	63	75		0	25	75	13	0	88	0	0	63	38	50	25	75	0	0	13	25	0	0
	63	Forecasting of the outbreak and scale of pyroclastic flows (nuee ardente, etc.) accompanying volcanic eruption to be realized.	1	60	7	15	78	72	49	42	7	2	10	32	80	17		10	22	50	12	2	72	3	12	68	25	25	2	60	0	0	10	13	2	0
			2	53	11	13	75	75	50	48	2	0	6	30	79	11		8	21	49	13	2	72	0	9	70	25	25	2	66	0	0	8	11	2	0
			X	6	100	0	0	90	80	20	0	0	17	67	50	17		17	33	67	17	0	100	0	0	67	50	33	0	83	0	0	17	33	0	0
Common/other (marine/earth science)	64	Elucidation of the entire aspect of the movement and storage of carbon dioxide extending over the air, land, oceans, and sea bottoms.	1	201	11	33	56	77	57	40	4	0	14	97	17	38		2	11	84	44	1	49	1	9	72	38	26	13	66	4	0	18	4	3	0
			2	170	10	31	59	79	58	41	1	0	10	95	7	31		2	8	83	42	0	49	1	9	80	35	21	7	73	1	1	19	2	3	1
			X	17	100	0	0	97	94	6	0	0	18	88	18	41		6	6	100	59	0	59	12	0	82	29	35	24	71	6	6	18	6	6	0
	65	Development of a positron microscope.	1	15	7	13	80	50	20	47	27	7	20	7	0	80		7	40	53	20	0	20	0	27	33	27	47	0	27	0	0	13	7	7	0
			2	17	6	18	76	53	19	56	25	0	18	6	0	88		6	35	53	12	0	18	0	24	29	24	59	0	35	0	0	18	6	12	0
			X	1	100	0	0	100	100	0	0	0	0	0	0	100		0	0	0	0	0	100	0	0	100	100	0	0	100	0	0	0	0	0	0
	66	Practical use of high-luminosity radiation via electron or positron storage rings with emittance of 0.1 nano radians or less, for use in analysis of the atomic structure of materials deep inside the earth.	1	18	11	28	61	60	33	44	17	6	22	28	11	78		6	22	61	44	0	44	0	33	33	28	50	11	50	0	0	6	6	6	0
			2	16	13	25	63	63	31	56	13	0	13	25	0	88		6	19	69	38	0	44	0	25	38	19	63	0	69	0	0	6	6	13	0
			X	2	100	0	0	63	50	0	50	0	0	0	0	100		0	0	100	100	0	100	0	0	50	50	50	0	100	0	0	0	0	0	0
	67	Practical use of neutron spectrographs via megawatt-class spallation neutron sources, for use in analysis of the atomic structure of materials deep inside the earth.	1	17	12	24	65	59	35	35	24	6	12	29	12	71		6	18	59	29	6	29	0	35	41	41	41	6	59	0	0	6	12	0	0
			2	14	14	21	64	61	36	36	29	0	7	7	0	71		7	14	71	14	7	21	0	21	21	43	43	0	79	0	0	7	21	0	0
			X	2	100	0	0	63	50	0	50	0	0	0	0	100		0	0	100	50	0	100	0	0	50	50	50	0	100	0	0	0	0	0	0
	68	Practical use of 0.1-1.0 nm wavelength lasers, facilitating the observation of material structures via hard X-ray holography.	1	26	15	19	65	59	32	44	20	4	27	27	0	81		12	15	50	27	4	38	0	38	35	46	42	4	50	0	0	8	8	4	0
			2	23	17	17	65	60	30	48	22	0	17	22	0	78		9	13	70	22	4	35	4	22	43	39	39	0	74	0	0	13	13	0	0
			X	4	100	0	0	100	100	0	0	0	25	50	0	100		25	0	100	50	25	75	0	0	100	50	50	0	50	0	0	25	25	0	0
	69	Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.	1	181	9	25	65	72	50	37	13	1	30	86	27	39		5	20	40	27	2	27	1	29	53	39	20	4	59	4	3	14	5	5	2
			2	157	9	23	68	78	59	35	6	0	25	88	17	34		4	13	52	33	3	32	0	27	63	42	14	3	76	3	2	15	1	2	2
			X	14	100	0	0	89	79	21	0	0	29	93	36	43		0	0	64	43	0	50	0	14	43	43	21	0	71	7	0	21	0	0	0
	70	Inauguration in Japan of international research centers for comparative planetology, including the science of the earth, based on the development of planetology through specimens obtained from meteorites and planets.	1	70	4	20	76	50	21	41	33	4	7	36	6	81		9	30	69	23	6	40	0	17	64	17	34	9	56	3	0	7	3	13	1
			2	65	5	17	78	52	20	48	32	0	2	32	2	85		9	25	83	22	3	45	0	9	80	12	35	5	66	0	0	5	2	15	2
			X	3	100	0	0	100	100	0	0	0	0	67	0	67		0	33	100	100	33	100	0	0	100	0	100	0	100	0	0	33	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)							Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Common/other (marine/earth science)	71	Widespread, systematic use of re-evaluation programs related to traditional technologies and living cultures, in order to enrich peoples lives through education.	1	103	4	11	85	63	33	52	14	1	42	15	58	37		1	18	26	28	1	16	0	38	29	30	21	6	48	10	5	1	4	26	0
			2	96	2	14	84	63	32	57	11	1	40	8	66	32		2	11	27	34	0	14	0	40	25	36	13	6	58	10	4	1	2	24	0
			X	2	100	0	0	63	50	0	50	0	0	0	50	100		0	50	50	50	0	0	0	50	0	50	0	0	0	100	0	0	0	0	0
	72	Widespread use of education and training systems for advanced career development planning (CDP), aimed at facilitating the acquisition of new knowledge and skills by middle-aged and elderly persons.	1	101	0	15	85	65	40	42	18	1	50	9	61	29		2	12	32	29	1	12	2	33	21	35	25	2	48	19	4	1	3	27	2
			2	92	0	16	84	64	36	49	14	1	55	4	63	20		4	8	40	35	0	8	0	34	17	39	22	2	59	14	3	1	1	23	2
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	73	Widespread construction throughout Japan of marine museums.	1	185	5	29	66	52	20	49	28	3	28	29	35	51		14	17	48	30	1	16	2	29	25	26	28	4	50	5	2	8	1	18	2
			2	167	5	26	69	52	19	52	28	1	21	23	37	61		9	10	68	40	1	15	2	20	25	26	29	3	65	5	4	5	1	16	2
			X	9	100	0	0	81	67	22	11	0	44	22	33	56		22	0	67	44	0	22	11	11	33	44	33	0	56	11	0	0	0	11	0
	74	Adaptation of natural history and scientific education methods to hands-on science museums capable of developing scientific skills in an enjoyable and playful atmosphere, and their spread throughout Japan.	1	179	4	21	75	62	35	44	21	1	35	23	39	54		3	16	58	31	2	15	1	25	31	28	28	2	56	7	3	6	1	17	2
			2	164	4	21	75	63	32	55	13	0	35	17	41	62		2	9	73	34	1	16	1	19	32	27	28	2	69	7	2	3	1	15	2
			X	7	100	0	0	86	71	29	0	0	43	14	43	57		0	0	71	71	0	29	0	0	29	57	29	0	71	14	0	0	0	29	0

(Note) See page 7 for the interpretation of the graphs.

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