Press Releases

August 3, 2010
Japan Agency for Marine-Earth Science and Technology

Japanese Waters are Biodiversity Hotspot
- Home to 14.6%(Note1) of Global Marine Species -

Overview

Scientists from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the Field Science Education and Research Center, of Kyoto University, and the Atmosphere and Ocean Research Institute, of the University of Tokyo, have created comprehensive inventories of marine life in the exclusive economic zone (EEZ) of Japanese waters, by compiling scientific papers and historical records on marine biota.

The results showed an amazing species diversity of marine life, which accounts for 14.6 %(Note1) of all marine species described from global oceans, and qualifies the Japanese waters as a "biodiversity hot spot." The number of described species (NDS) was found to make up only 20 % of all species expected to occur in Japanese waters. The study was led by Dr. Katsunori Fujikura, Institute of Biogeosciences, JAMSTEC, in collaboration with about 50 taxonomic experts in Japan.

The findings include:

- A total of 33,629 species have been reported to occur in Japanese waters, encompassing from bacteria to mammals.
- Of the NDS, the phylum Mollusca had the highest value of 8,658, followed by the Arthropoda (6,393).
- The total number of identified but undescribed species (NUS) was 121,913.
- The combined total with both the NDS and NUS represents the expected number of species in Japanese waters (15,542).
- The number of known introduced species (NIS) stood at 39.
- The state of knowledge was significantly variable depending on taxa.

Evidenced by some comparisons of taxonomic data with those from other oceans, Japanese waters are known to have a rich marine species diversity; yet, this study was the first attempt to comprehensively estimate species richness for all marine organisms in Japanese waters. The results revealed an astonishing diversity of marine life, much higher than the world average.

The findings have been published online on August 2, 2010, in the Public Library of Science One (PLoS One).

Title	:	Marine Biodiversity in Japanese Waters
Authors	:	Katsunori Fujikura, Dhugal Lindsay, Hiroshi Kitazato, Shuhei Nishida, Yoshihisa Hirayama

Background

To achieve a sustainable coexistence between human activity and marine organisms, it is crucial to understand biological diversity and ecosystem functioning of marine life as well as correctly assessing the impacts from

global environmental change and anthropogenic activity.
Taxonomic inventories of marine life and its diversity were essential, but much work had yet to be done. At this backdrop, scientists around the world set forth a ten-year project called the "Census of Marine Life (CoML)(*1)" in 2000 to quantitatively estimate diversity, distribution, and abundance of marine species so that the results could serve to a better understanding of marine species richness and ecosystems. The project involves efforts in regional and international levels, setting up 13 National and Regional Implementation Committees (NRICs) in the world to collect marine diversity data. The study presented here is part of such activities for NRICs. The findings along with those from Australia, New Zealand, Mediterranean Sea, Caribbean Ocean, South Africa, Antarctica and U.S have been published in the August 2 issue of PLoS One, as well as in a press release by CoML.

A variety of marine habitats in Japanese waters are considered to contribute to a rich alley of marine species. Surrounded by such waters, marine products have always been one of the popular ingredients for Japanese dishes. Alteration in marine ecosystems induced by global environmental change and human activity will therefore, have significant effects on the Japanese lifestyle. In light of such importance of marine resources, taxonomical, ecological and physiological studies have been actively performed in Japan.

In order to set a baseline for understanding the marine biodiversity in Japanese waters (including territorial waters and the exclusive economic zone), researchers complied information on marine biota and provided a comprehensive analysis.

Outline of method
Marine species in Japanese waters were classified into taxonomic orders, and species richness of each phylum was estimated using three indices - the number of described species (NDS), the number of endemic species (NES) and the number of known introduced species(NIS). There exist many species that were identified but undescribed or have no historical records because of our elementary knowledge of their taxonomy and ecology. The species richness in such cases was estimated as the expected number of species (ENS).

The state of knowledge concerning the taxonomy and ecology of taxa was classified into three categories -known, mostly unknown, unknown-for each phylum, based on the number of described species and their distribution, the number of identification guides and their published years, and the number of taxonomic experts in Japan. More than 50 experts on the taxonomy or ecology of marine organisms collaborated in gathering the species richness information(Table 1).

Results of the census of marine life in Japanese waters
1) Japanese waters as a hotspot of biodiversity: number of described species
The total number of descried species (tNDS) including bacteria to mammals (Table 2), was 33,629. Mollusca had the highest number of species, followed by crustaceans. Among 66 phyla (*2), the 10 phyla with the highest totals of the NDS comprised about 85 % of the tNDS (Figure 1).
According to The Ocean Biogeographic Information System(OBIS)(*11) , the total number of marine species described from the global ocean is estimated at about 230,000(Note2). Given the total volume of the Japanese waters, which makes up only 0.9% of the global ocean, the tNDS (33,629) accounts for 14.6%(Note1) of all marine species around the world.
This globally significant value of species richness qualifies Japanese waters as a biodiversity hotspot, which is considered to be attributed to a variety of marine environments shaped by wide-ranging topography, water depth, water temperature, currents, and climate zone.

2) Number of endemic species

The number of endemic species (NES) in Japanese waters was at least 1,872. Among them, Foraminifera (*3), Pisces and Gastropoda have high values, whereas Annellida had a very low NES and no records were found for Haptophyta(*4) endemic to Japanese waters.

3) Expected number of species (ENS)
The total number of identified but undescribed species(NUS) is estimated at 121,913 (Table 2). The combined total with both the NUS and tNDS (33,629) makes the best estimate of the number of species currently occurring in Japanese waters (155,542). This signifies that only 20% of all estimated species around Japanese waters have been described despite an exceptionally high NUS for Pisces. Gobiidae (or goby) had more than 200 undescribed species.

4) Species introduced to Japanese waters
The number of species introduced to Japanese waters (NIS) was 39, including 11 Mollusca, 10 each of the Annelida and Arthropoda, 3 Chordata, 2 Myxozoa(*5), and 1 of each of the Chlorophyta(*6), Cnidaria, and Heterokontophyta (*7). The presumed primary mechanism of transport is thought to be through hull fouling or in ballast water brought by ships, as well as through import of fisheries resources.

5) State of knowledge
The amount of taxonomical and distribution data available to date differs substantially among taxa (Table 3). The taxa with larger and conspicuous species (e.g. Chordata including fish and Mollusca) had a tendency to be better known and replete with information. On the other hand, some taxa that contain small species, such as Amoebozoa(*8) and Cycliophora(*9), are poorly described and little understood. Difficulties in sample collection and morphological identification due to the organisms being so small, as well as the lack of taxonomic expertise in Japan (and indeed around the world), are the major reasons for our lack of knowledge about these taxa. When compared with the NDS values for representative taxa occurring in Japanese waters published in 1981, NDS values for Amphipoda(Plylum Anthropoda), Hydrozoa(Phylum Cnidaria)(*10), and Asteroidea (Phylum Echinodermata) have increased considerably owing to taxonomic and ecological studies (Table 4).

Discussion and future perspectives
We expect rapid changes in marine biological diversity and ecosystems in Japanese waters including: (1) dining wild fish catches, (2) increase in aquaculture (3) changes in harvesting of specific species , (4) changes in harvested areas, (5) food web changes, (6) shifts in diversity at population, species and genetic levels, (7) species extinction, population extinction, (8) decline in genetic resources (9) changes in species distribution: contraction, expansion, and range shifts, (10) changing traffic patterns of animal migrations, (11) introduction of exotic species, (12)changes in nutrient cycles, and (13)changes in surface primary productivity and carbon fluxes to the seafloor. Yet, our knowledge is still elementary to properly understand benefits (ecosystem services) and marine ecosystem functions. It is essential to know what lives where in the ocean, how many of them occur, and what they do in marine ecosystems. This study provided valuable insights to these questions, while at the same time highlighting quantitative difference in taxonomic and ecological data among taxa. In addition, there are numerous unexplored areas in open waters, especially in the deep sea. Biological investigation in these areas, as well as filling gaps in knowledge among taxa is of great importance.

Databases are a powerful tool to comprehensively analyze changes in biodiversity and ecosystems. However, many databases concerning biodiversity and occurrence of marine species have different schema, requiring urgent measures to establish linkages between them. The Census of Marine Life has developed the Ocean Biogeographical Information System (OBIS) as its main repository of information. Yet, the number of species in Japanese waters recorded in OBIS is still small, illustrating the need for encouraging linkages between Japanese databeses and OBIS, alongside the development of analytical tools that incorporate the environmental background of Japanese waters.

The study set a baseline not only for marine biodiversity and ecosystem studies in Japan, but also for prediction of ecosystem changes, evaluation of biological resources, and environmental impact assessments.

Glossaries

*1 **The Census of Marine Life (CoML)** is a global network of researchers engaged in a ten-year initiative to assess and explain the past, present, and future diversity, distribution, and abundance of marine life in the oceans. Spanning from 2000 to 2010, it has involved over 2000 researchers in more than 80 nations. The ground finale of the CoML will be held in London in October 2010, with the world's first comprehensive census of marine life to be presented in the British Museum.

*2 **Phylum** is one of taxonomic orders.

*3 **Foraminifera** are a group of organisms with shells made of calcium carbonate, measuring less than 1mm in size. Sand grains called "star sand" are the shells of Foraminifera. They live on land and in the water, even at the deepest part of the Earth. They are a predominant component of the deep-sea biomass

*4 **Haptophyta** is a group of micro-algae including Coccolithophore, usually 5~50μm in size. They are basically planktonic.

*5 **Myxozoa** are a group of parasitic animals living off fish. The average size of them are 10~20μm.

*6 **Chlorophyta** are a division of green algae living in aquatic and terrestrial environments. Ulva and Chlamydomonas belong to this group.

*7 **Heterokontophyta** is a group of algae containing species ranging from well-known large algae, such as Konbu(Laminariales) and Wakame (Undaria), to diatom.

*8 **Amoebozoa** is a group consisting chiefly of amoeboid (unicellular)organisms about 10-20 μm in size.

*9 **Cycliophora** are peculiar microscopic animals, found living attached to the mouth of lobsters. Only a few species belong to this group.

*10 **Hydrozoa** belong to Phylum Cnidaria. Genus Hydra and the largest known solitary hydroid Branchiocerianthus imperator Allman are among them.

*11 **Ocean Biogeographic Information System(OBIS)** is a database for marine diversity and biogeographical information. It contains more than 110,000 species records and 28 million records on their locations.

Table 1. Contributors for species diversity estimation

Taxon		Contributor (Institution/Affiliation[1])
Archaea		Hiroyuki Yamamoto (JAMSTEC)
Bacteria		Yuichi Nogi (JAMSTEC), Hiroyuki Yamamoto (JAMSTEC)
Eukarya	Acoelomorpha	Ken-ichi Tajika (Nihon University)
	Ascomycota	Takahiko Nagahama (JAMSTEC)

	Annelida	Eijiro Nishi (YNU)
	Arthropoda	Kouki Fukuoka (SNF), Mark J. Grygier (LBM), Nozomu Iwasaki (Kochi University), Tomoyuki Komai (NHMIC), Kazuya Nagasawa (Hiroshima University), Koichiro Nakamura, Susumu Ohtsuka (Hiroshima University), Takashi Onbé (Hiroshima University), Nobuhiro Saito (Suido-sha), Shozo Sawamoto (Tokai University), Michitaka Shimomura (KMNH), Hiroshi Ueda (Kochi University), Toshiyuki Yamaguchi (Chiba University)
	Basidiomycota	Takahiko Nagahama (JAMSTEC)
	Brachiopoda	Hiroshi Kajihara (Hokkaido University)
	Cercozoa	Noritoshi Suzuki (Tohoku University)
	Chaetognatha	Taichiro Goto (Mie University), Kazunori Kuroda (JSNFRI)
	Chlorophyta	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)
	Chordata	Naoki Kohno (NMNS), Keiichi Matsuura (NMNS), Tsukasa Murayama (Tokai University), Jun Nishikawa (University of Tokyo), Naonobu Shiga (HJC)
	Ciliophora	Miwa Nakamachi (TNFRI)
	Cnidaria	Yukimitsu Imahara (BIK), Shin Kubota (Kyoto University), Keiichi Nomura (KMPC), Hiroyuki Tachikawa (NHMIC), Kensuke Yanagi (NHMIC)
	Ctenophora	Takushi Horita, Ryo Minemizu (Ryo Minemizu Photo Office)
	Dicyemida	Hidetaka Furuya (Osaka Univ)
	Dinophyta	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)
	Echinodermata	Toshihiko Fujita (NMNS)

	Ectoprocta	Hiroshi Kajihara (Hokkaido University)
	Entoprocta	Toru Iseto (JAMSTEC)
	Glaucophyta	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)
	Granuloreticulosa	Shiro Hasegawa (Kumamoto University)
	Haptophyta	Masanobu Kawachi (NIES)
	Magnoliopsida	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)
	Metamonada	Naoji Yubuki (UBC)
	Mollusca	Takashi Okutani (JAMSTEC), Hiroshi Saito (NMNS)
	Myxozoa	Hiroshi Yokoyama (University of Tokyo)
	Nemertea	Hiroshi Kajihara (Hokkaido University)
	Ochrophyta	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)
	Oomycota	Shigeki Inaba (NITE)
	Orthonecta	Hidetaka Furuya (Osaka Univ)
	Phoronida	Hiroshi Kajihara (Hokkaido University)
	Placozoa	Hiroshi Kajihara (Hokkaido University)
	Platyhelminthes	Ken-ichi Tajika (Nihon University)
	Porifera	Yuji Ise (University of Tokyo)
	Radiozoa	Noritoshi Suzuki (Tohoku University)
	Rhodophyta	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)
	Streptophyta	Jiro Tanaka (TUMSAT), Hidekazu Suzuki (TUMSAT)

Table 2. List of species diversity including the number of described species (NDS), the number of undescribed species (NUS), expected number of species (ENS), and the number of introduced species (NIS)

Taxonomic order			NDS	NUS	ENS	NIS
Domain	kingdom					
Archaea			9	–	9	–
Bacteria			843	1	844	–
Eukarya	Chromista					
		Phaeophyta (Phaeophyceae)	304	–	304	1
		Other Chromista	943	–	943	–
	Plantae	Chlorophyta	248	–	248	1
		Rhodophyta	898	–	898	0
		Angiospermae	44	–	44	0
		Other Plantae	5	–	5	–
	Protista					
		Dinomastigota	470	–	470	0
		Foraminifera	2,321	490	2,811	0
		Other Protista	1,410	104	1,514	0
	Fungi		367	–	367	0
	Animalia					
		Porifera	745	540	1,285	0
		Cnidaria	1,876	350	2,226	1
		Platyhelminthes	188	350	538	0
		Mollusca	8,658	1,180	9,838	11
		Annelida	1,076	–	1,076	10
		Crustacea	6,232	1,657	7,889	10
		Bryozoa	300	900	1,200	0
		Echinodermata	1,052	–	1,052	0
		Urochordata (Tunicata)	384	8	392	2
		Other invertebrates	1,314	115,969	117,283	2
		Vertebrata (Pisces)	3,790	364	4,154	1
		Other vertebrates	152	–	152	0
	Ttoal of Eukarya		32,777	121,912	154,689	39
Total			33,629	121,913	155,542	39

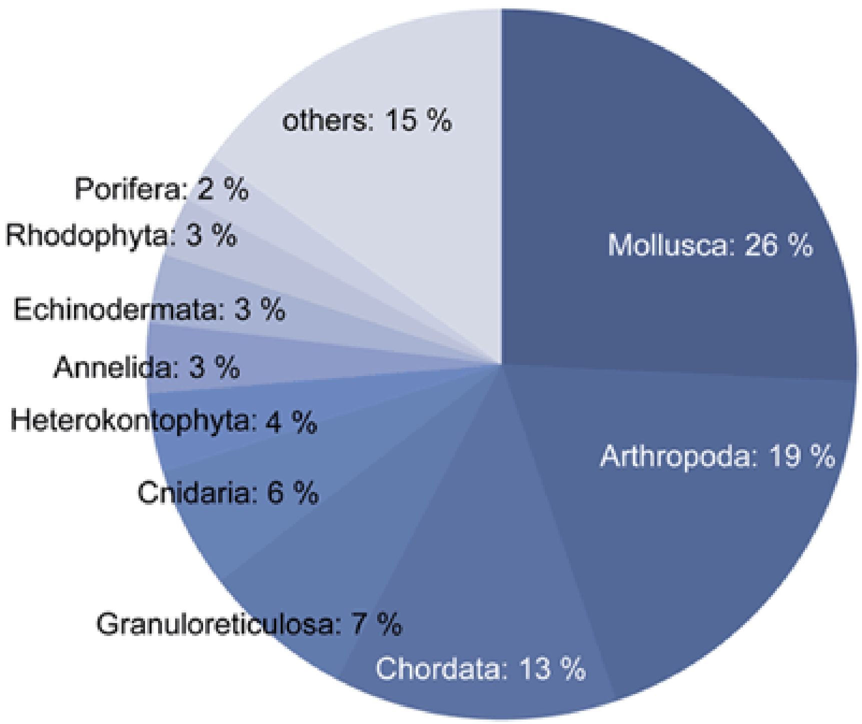

Figure 1. Percent ratio of the number of described species (NDS) in respective phyla

Table 3. Current taxonomic status, Known, Mostly unknown and Unknown, for each Phylum or Division.

Taxonomic status

Known	Mostly unknown		Unknown
Acoelomorpha	Acidobacteria	Hemichordata	Acanthocephala
Bacteroides	Actinobacteria	Heterokontophyta	Amoebozoa
Cercozoa	Annelida	Kinorhyncha	Apicomplexa
Chaetognatha	Aquificae	Loricifera	Blastocladiomycota
Chlorophyta	Arthropoda	Metamonada	Chytridiomycota
Choanozoa	Ascomycota	Nematoda	Cycliophora
Chordata	Basidiomycota	Nematomorpha	Glomeromycota
Ctenophora	Brachiopoda	Nemertea	Heliozoa
Dicyemida	Cnidaria	Orthonecta	Oomycota
Echinodermata	Crenarchaeota	Phoronida	Opalozoa
Ectoprocta/Bryozoa	Cryptophyta	Placozoa	Percolozoa
Granuloreticulosa	Deinococci	Porifera	Thaumarchaeota
Haptophyta	Dinomastigota	Proteobacteria	
Labyrinthulomycota	Echiura	Sipuncula	
Magnoliopsida	Entoprocta	Tardigrade	
Mollusca	Euglenophyta	Thermotogae	
Myxozoa	Euryarchaeota	Verrucomicrobia	
Radiozoa	Gastrotricha	Zygomycota	
Rhodophyta	Glaucophyta		
Rotifera	Gnathostomulida		

Table 4. Comparison of number of described species in selected taxa between present study and a previous study by Nishimura (1981) [19].

Taxon			NDS[1] of previous study [19]	NDS of present study	Increase of NDS[2]
Phylum	Class	Order			
Chordata	Pisces		2700	3790	1090
Cnidaria	Hydrozoa		315	523	208
Chordata	Ascidiacea		281	313	32
Echinodermata	Ophiuroidea		ca. 260	308	48
Echinodermata	Echinoidea		192	161	-31

Echinodermata	Asteroidea		167	280	113
Platyhelminthes	Polycladida	Polycladida	149	150	1
Porifera	Calcarea		130	130	0
Mollusca	Cephalopoda		125	204	79
Arthropoda	Pycnogonida		67	153	86
Sipuncula			58	47	-11
Arthropoda	Crustacea	Amphipoda	57	544	487
Mollusca	Polyplacophora		56	129	73
Brachiopoda			55	73	18
Arthropoda	Crustacea	Stomatopoda	41	56	15
Cnidaria	Scyphozoa		38	37	-1
Echiura			17	21	4

[1] Number of described species.
[2] Difference between NDS reported in Nishimura (1981) [19] and NDS of the present study.

The number has been changed as follows by the latest research.
Note1 : 13.5%
Note2 : 250,000
(Added August 10, 2012)

Contacts:
Japan Agency for Marine-Earth Science and Technology
(For the study)
Katsunori Fujikura
Team Leader, Marine Biodiversity Research Program
Institute of Biogeosciences (Biogeos)

(For publication)
Toru Nakamura, e-mail: press@jamstec.go.jp
Manager, Planning Department Press Office