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Strategies and Methodology of Marine Biodiversity Studies[1]

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Abstract—This paper reviews major global and regional international approaches to inventory and monitoring of biological diversity. The current strategy of studying marine biodiversity is outlined. We also discuss the methodology of marine biota inventory at the regional level within the framework of the long-term biodiversity studies in the West and North Pacific Ocean that are undertaken by the international institutions *Census of Marine Life, DIWPA*, and *NaGISA*. The paper also contains data on the biological diversity of Russian Far East seas.

Key words: biological diversity, marine ecosystems, monitoring, videomonitoring.

The problems of biodiversity studies and conservation have received a great deal of attention over the last decade, at least in the declarative sense. In 1992, the Convention on Biological Diversity was signed by 157 governments at the Earth Summit, which took place in Rio de Janeiro. It was also approved by Russia in 1995. The Darwin Declaration (The Global Taxonomy Initiative) was accepted at the meeting on biodiversity conservation held in Darwin (Australia) in 1998 and was ratified by 170 countries. UNESCO declared 2001 the Year of Biodiversity. The national forum of experts, which was held in Moscow in June 2001, endorsed the National Strategy for Biodiversity Conservation.

Earlier, in 1990, the International Union of Biological Sciences (IUBS), UNESCO, and the program *Man and the Biosphere* had organized the first global international program called DIVERSITAS for studying and monitoring biodiversity and ecosystem function.

In the 1990s, the Intergovernmental Oceanographic Commission of UNESCO undertook a project aimed at the development of a UNESCO-IOC Register of Marine Organisms, which included an annotated checklist of all marine species, each of which was assigned a ten-digit code according to the system of the US Oceanographic Data Center (NODC).

In December 2003, a large-scale regional program entitled DIWPA (Diversitas in Western Pacific and Asia) was established within the framework of DIVERSITAS for promoting cooperative studies on biodiversity and ecosystems in the region of the Western Pacific, which exhibits the highest level of biodiversity on the Earth. DIWPA aims to develop regional cooperative programs that focus on biodiversity inventory and monitoring, as well as on the role of biodiversity in ecosystem function. One of the major DIWPA activities is development and application of the regional strategy for studying and monitoring marine biodiversity in the coastal ecosystems from the subarctic areas of Russian Far East seas to New Zealand [6].

In the beginning of the 21st century, one of the most important global programs called *Census of Marine Life, CoML*, was established to assess and explain marine biological diversity, distribution and abundance of marine hydrobionts in the world's oceans. This program, which will conclude in 2010, includes several major projects, one of which (NaGISA—Natural Geography in Shore Areas) aims to assess and study marine biodiversity in the macrophyte coastal communities of the West and North Pacific Ocean areas.

Awareness of the huge level of biodiversity in the ocean, the extremely poor current state of knowledge on this subject, high extinction rates of modern species, an insufficient number of taxonomists, and slow progress in describing existing species have called for a new ideology and strategy for marine biodiversity studies. Under the conditions of the modern biodiversity crisis [8], this strategy involves selection of areas that display the highest level of diversity (in a given climate zone and latitude range) for a comprehensive study, inventory, and monitoring by international institutions and research groups. The strategy comprises four major phases: (1) identification of centers of evolutionary diversification (major centers of species and genetic diversity) by integrated surveys and inventories, (2) location of a monitoring site within the selected

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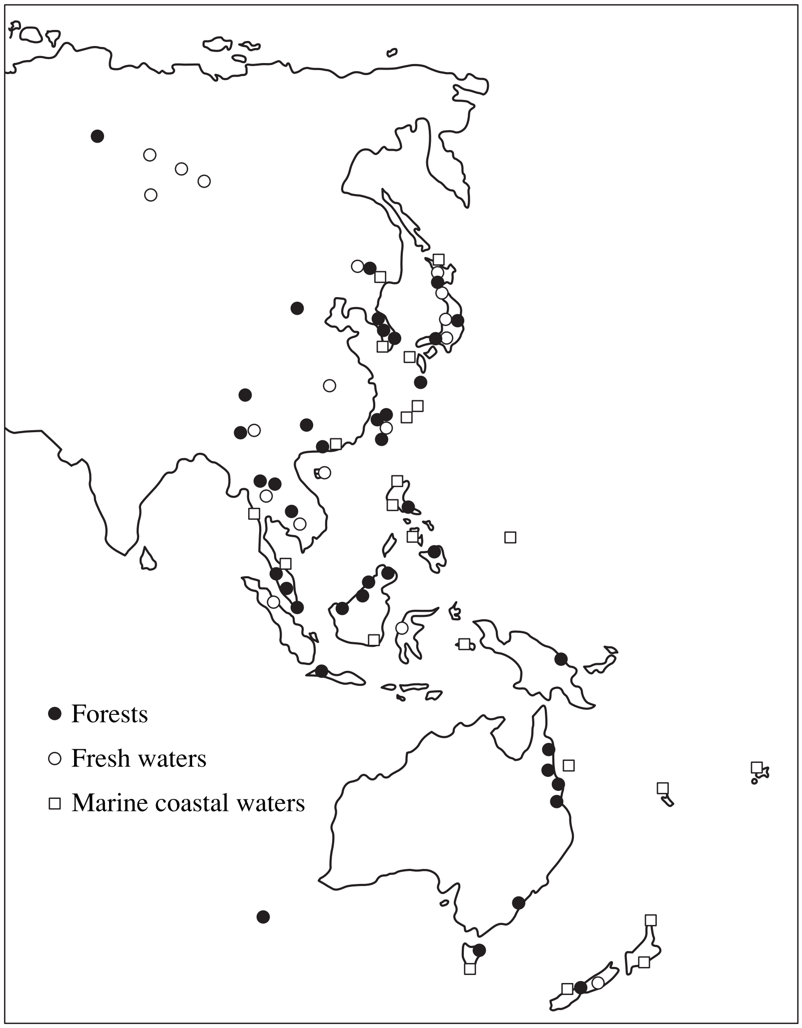

Fig. 1. Location of water areas and land stations recommended by DIWPA for monitoring along long-term transects in three major ecosystem types (forest, fresh water environments, and coastal marine areas).

(protected) area, (3) publication of comprehensive identification guides (keys) to the biota of the studied area (also in electronic form that can be accessed through the Internet), and (4) studies of biodiversity in these selected areas at all other levels.

This strategy was formulated and approved at DIWPA meetings, which developed standardized methodologies recommended to the research groups of the member countries [5]. The start of the new millennium saw the launch of a new initiative of DIWPA entitled the International Biodiversity Observation Year (IBOY), which aimed to (1) create an international network of research institutions to develop methods of inventorying and conserving biological objects and (2) to bring international research groups together to study the role of biodiversity in various ecosystems by inventorying and monitoring in three major ecosystem types (forest, freshwater, and coastal marine environments) using standardized methods. The specific goals were (1) to select areas for surveying and (2) to develop standardized methods, which were obligatory for all the members of the program, thereby ensuring that results obtained by research groups in different countries were comparable.

Based on the data on the biodiversity in the West Pacific, 21 areas for studying coastal marine habitats were selected by the branch of DIWPA for surveying and long-term annual monitoring (50 years) (Fig. 1). In the Russian Far East seas, at the suggestion of the Institute of Marine Biology of FEB RAS (IMB FEB RAS), one of these areas was established in Peter the Great Bay (Sea of Japan), which exhibited the highest level of biological diversity in the corresponding latitude range. In 2002, hydrobiological surveys started in this area along the standardized long-term transects (see [5]). In 2002–2003, the Regional Center of NaGISA in the West Pacific (Japan) took over from DIWPA the functions of coordinating estimates and long-term monitoring in the selected 21 areas in the West Pacific Ocean.

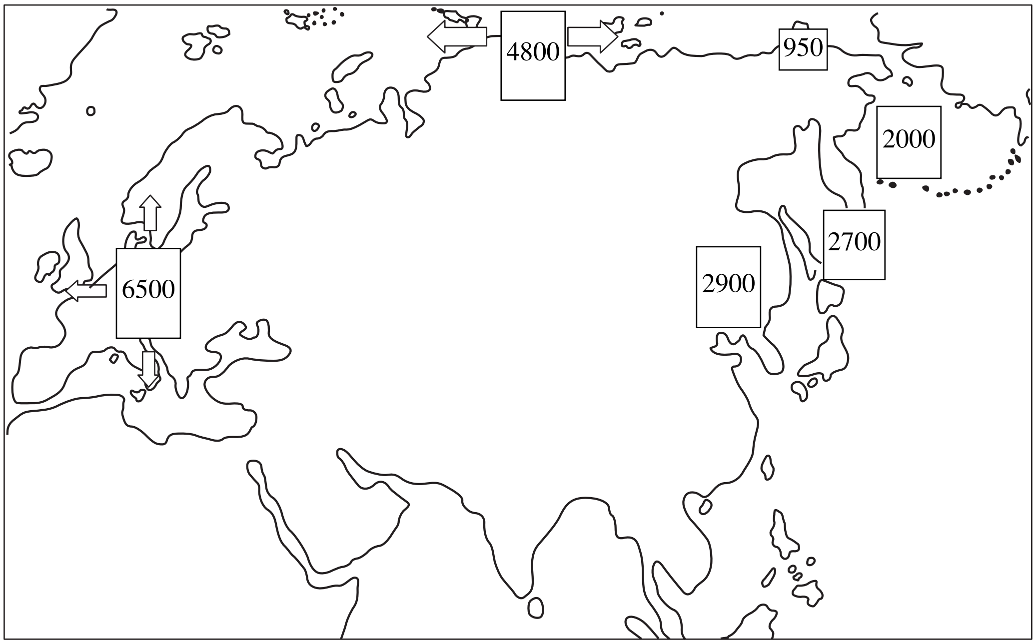

Fig. 2. Number of marine invertebrate species registered in European seas, Arctic basin, and Russian Far East Seas. Numbers indicate the number of invertebrate species recorded in the seas off Europe (6500), Russian Arctic waters (4800), Chuckchee Sea (950), Bering Sea (2000), Sea of Okhotsk (2700), and the Sea of Japan (2900, of which 2600 have been found in Peter the Great Bay).

According to the data of the Zoological Institute of RAS (ZIN RAS), about 6900 invertebrate species, most of which are macrobenthic animals (crustaceans, mollusks, and annelids), have been registered in the Russian Far East Seas so far [3]. This number is greater than the total number of invertebrate species found in the coastal waters of Europe (6500) and in the Russian Arctic waters (4800) (Fig. 2) [4, 7]. The Sea of Japan exhibits the highest level of biodiversity. It comprises 42% of the total species number recorded in the Far East seas. About 2900 invertebrate species have been found in the Sea of Japan. It is greater than the number of invertebrate species recorded in the Sea of Okhotsk (2700) and Bering Sea (2000), and nearly three times greater than that in the Chuckchee Sea (950) (Fig. 2) [3]. Most of these species were registered in coastal waters, which are relatively well studied in terms of marine biota diversity. For instance, the estimates of the Zoological Institute of RAS [2, 3] suggest that about 30% of turbellarians and 40% of scyphozoans inhabiting the coastal environments of the Far East seas have already been discovered. Moreover, the percentage of known species of bryozoans, mollusks, decapods, echinoderms, and ascidians is as high as 80–90%. These estimates do not involve deep-sea macrobenthos and meiofauna. However, the proportion of discovered coastal macrobenthic species seems to exceed 60% [3].

In Russian seas, and in the Russian part of the Sea of Japan in particular, Peter the Great Bay is the richest area in terms of species and taxonomy. A unique combination of warm and cold currents, climate conditions, and a variety of bottom and coastal landscapes together support a wealth of biological resources and make this region one of the most interesting and promising for long-term biodiversity monitoring at the local level, according to the standardized methods of DIWPA.

According to the data of IMB FEB RAS, nearly 4000 marine species belonging to 52 phyla and 105 classes have been registered in Peter the Great Bay to date (Fig. 3) [1]. Of these, 2600 species are marine invertebrates.

The species composition of Peter the Great Bay is not only diverse, but also unique due to a combination of various natural conditions. In spite of a relatively small size, this habitat is shared by boreal-arctic, boreal, low-boreal, subtropical, and even tropical species of marine invertebrates and fish. The bay is home to about 640 species of marine unicellular and multicellular algae including commercially valuable species (*Ahnfeltia, Agarum*, and three species of the genus *Laminaria*), which are used in the food industry and medicine; 70 species of marine fungi; about 100 coelenterate species; 222 flatworm species; 178 roundworm species; 277 annelid species; over 320 mollusks including commercially valuable species (Japanese scallop, mussel, oyster, *Neptunea*, *Buccinum*, and cephalopods: squids and octopuses); 620 crustacean species, many of which are of commercial value (red king crab, blue king crab, spiny king crab, hair crab, and some tens of shrimp species); 74 echinoderm species of which the Japanese sea cucumber (*Apostichopus japonicus*), *Cucumaria japonica*, and eight sea urchin species are commercially valuable; over 200 fish species ranging from abundant common commercial fish

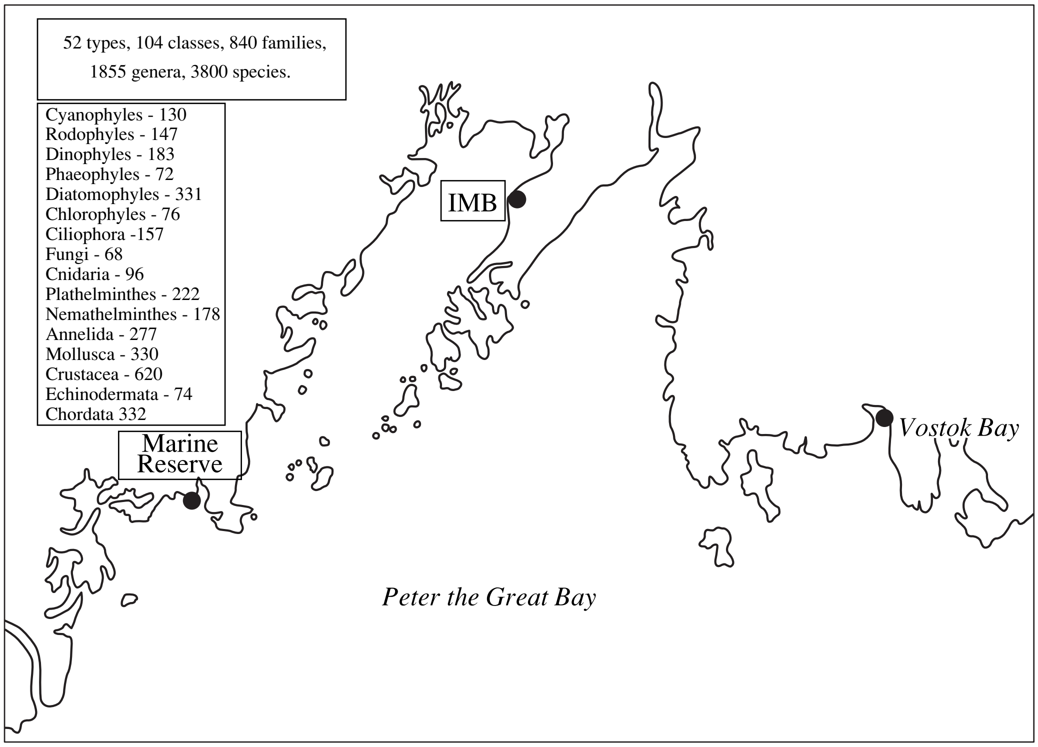

Fig. 3. Taxonomic diversity in Peter the Great Bay (Sea of Japan) (after [1]). Circles indicate the location of submarine transects for long-term biodiversity monitoring. IMB—Institute of Marine Biology FEB RAS.

to subtropical species (fugu fish, sea horses). Two species of marine turtles, two species of marine snakes, about 60 species of marine birds and birds that feed on marine organisms, and more than 15 species of marine mammals have also been registered in the bay [1].

The majority of the species diversity of Peter the Great Bay is concentrated in its southwest warm water area that belongs to the only marine reserve in Russia.

Since Peter the Great Bay includes the marine reserve and Vostok Bay Marine Sanctuary, IMB FEB RAS, at the suggestion of DIWPA, uses not only the standardized protocol for hydrobiological surveys [5], but has also developed, for the first time in Russia, the method of videomonitoring of marine biota along the long-term fixed transects, which run through all types of seafloor landscapes. Regular video scanning of the seafloor along long-term transects in no-touch areas was initially developed and applied to study the biological diversity of the coral reefs off the Florida Islands (north Caribbean Sea) and in the Great Barrier Reef. This method was shown to be highly useful for assessing and controlling the dynamics of reef communities.

In April 2003, NaGISA organized an international workshop on large-scale marine biodiversity studies in the North Pacific within the framework of the global program *Census of Marine Life*, which took place in Fairbanks (Alaska, USA). As a result, an international project was developed that involved inventorying of marine biota along a latitudinal transect, which would run a total of 2000 nautical miles from the coast of Alaska to the Kamchatka Peninsula adjacent to the Aleutian and Commander Islands. In 2004, IMB FEB RAS and the University of Alaska (Fairbanks) are going to start a two-year series of marine research expeditions using the facilities of the FEB RAS research fleet. As in the case of studies along the transects in the West Pacific, the hydrobiological surveys will follow the standardized DIWPA protocol and will use videomonitoring. The inventory of marine biota along the latitudinal transect will help to solve some major problems in biogeography concerning the distribution of boreal and arctic species in the West and East Pacific and to test the existence of so-called biogeographic breaks between the Aleutian Ridge and the Aleutian and Commander Islands.

In conclusion, it may be said that the National Strategy for Biodiversity Conservation has been endorsed, the International Strategy for Marine Biodiversity Conservation has been developed, and the methodology for studying and monitoring marine biodiversity in the West and North Pacific has been established both at the regional and local levels. Much interesting and important work remains to be done in this field; it will require close cooperation of marine biologists from all the countries of the region.

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