Sources of Ingress and Distribution of Marine Litter Along the Coast of Primorsky Krai

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Abstract. The World Ocean pollution with production and consumption waste is one of the hottest global environmental problems of today. The term "marine litter" has already become firmly established in the scientific use, and in both Russian and world research literature it is defined as any manufactured or processed material, directly or indirectly, intentionally or unintentionally left in the marine environment. It is plastics and its elements that account for a considerable share of marine litter. Research on the pollution of the beaches of Primorsky Krai with marine litter has been carried out since 2007 to the present. These were first conducted on the shores of the Amursky and Ussuriysky bays (Japan sea) and were timed to coincide with the International Coastal Cleanup (ICC) action to clean up the shoreline from marine litter. Over the period of from 2007 to 2021, more than 160 studies were carried out at 74 locations along the Primorsky Krai coast. The findings from the monitoring have revealed 85 per cent of waste found the Primorsky Krai coastal-marine areas have been formed through recreational activities. The analysis of the monitoring results made it possible to work out a number of recommendations to control the situation with Primorsky Krai coastal-marine areas' pollution with marine litter.

1. Introduction
The World Ocean pollution with production and consumption waste is one of the hottest global environmental problems of today. The term "marine litter" has already become firmly established in the scientific use, and in both Russian and world research literature it is defined as any manufactured or processed material, directly or indirectly, intentionally or unintentionally left in the marine environment. [1].

It is plastics and its elements that account for a considerable share of marine litter [2] Recognizing the calls of the global environmental community for a speediest solution to the problem of a planetary scale, the 14th meeting of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, held in May 2019, adopted the amendments to the annexes of the Convention in terms of classifying plastics as requiring special consideration [3].

Plastic, plastic material, plastics are the materials based on synthetic or natural high molecular weight compounds (polymers). Plastics based on synthetic polymers have gained a widespread use. Lightweight, durable and affordable, plastic has become a convenient replacement for metal, glass and wood and is used in all fields of endeavor (cosmetology, medicine, construction, household use, etc.). However, along with the obvious advantages, there are a number of significant disadvantages. The
latter, firstly, are conditioned by a long period of destruction of plastic: calculations show that disposable plastic tableware takes approximately 400 – 500 years to be decomposed. Furthermore, in the process of interaction with water, air, sunlight certain toxic substances (formaldehydes, bisphenol A, etc.) are emitted into the environment, affecting all living organisms, including humans.

2. Material and methods

Research on the pollution of the beaches of Primorsky Krai (PK) with marine litter been carried out since 2007 to the present. These were first conducted on the shores of the Amursky and Ussuriysky bays and were timed to coincide with the International Coastal Cleanup (ICC) action to cleanup the shoreline from marine litter. This action was initiated by the Ocean Conservancy, a non-profit environmental group, in 1986, one of its priorities being not only cleaning the coast, but also monitoring pollution in order to make management decisions.

The geography of Russian research is constantly expanding. Thus, since 2009, they include the northeastern regions of Primorsky Krai (Olginsky, Terneisky districts), which has made it possible to identify differences in the composition and quantities of waste. The northern and southern parts of the Primorye coast differ significantly in their climatic and hydrodynamic parameters. Besides, the south of Primorsky Krai is characterized by a more developed infrastructure and during the recreational season it attracts tourists from all over the Far Eastern Federal District of the Russian Federation.

Over the period of from 2007 to 2021, more than 160 studies were carried out at 74 locations along the Primorsky Krai coast. Monitoring beach pollution with marine litter was carried out both during the ICC campaign and during additional field research studies. The original intention of the organizers of the ICC was to expand the geography of research to the greatest extent possible. This strategy, implemented in the first years, made it possible to identify recreation as the main source of polluting the Krai coasts with marine litter [4]. Then, through analyzing the data obtained the main trends in the distribution of marine litter, its qualitative and quantitative composition were established, the predominant sources of pollution were identified, which subsequently made it possible to best space the monitoring stations (Fig. 1).

When conducting research, the marine litter identification is carried out at the model site in accordance with the recommended Ocean Conservancy blank form [5]. A model site for each beach is selected on a case-by-case basis, taking into account hydrodynamic activity and covers the supralittoral and littoral zones. In case of the south of the Primorsky Krai, it is typically located in the central part of the beach. The average area of the monitoring site is 50 sq.m. It has been experimentally established that such an approach gives a clearer picture of the distribution of the litter along on the beach, and allows assessing the pollution load and its constituent parts, as well as identifying possible sources of pollution emission subsequently. This is followed by marine litter collection and identification in terms of the number of items given in the blank form (i.e. foodstuff packaging, fishing tackle, etc.). Statistical analysis of the data obtained as a result of field research also revealed differences in the composition of litter encountered in different areas of the Primorsky Krai and that proposed in the recommended Ocean Conservancy blank form, therefore, certain correction were made with the blank form to account for the specifics of the marine litter found in the region [6]. Also, an additional parameter has been introduced into the updated blank form for entering the data, namely the classification of waste by its morphological characteristics (plastic, glass, metal, and others) with an indication of the weight of each category. This information is important from the point of view of establishing the principles of waste management. The results obtained are entered into a database and forked in the world TIDES system, supported by the Ocean Conservancy [7].
Figure 1. Marine litter monitoring stations correlated with various types of recreational activities.

For the purposes of environmental activity public awareness raising campaign, environmental education, as well as for representing the global nature of the problem, statistical bulletins are published annually, including those in the format of infographics (Fig. 2).

Figure 2. Ocean Conservancy sample infographics [8].
Thus, in the course of many years of practice and based on the analysis of various methods for monitoring coastal pollution with marine litter, a typical monitoring algorithm has been developed (Fig. 3).

**Figure 3.** Algorithm for conducting monitoring the pollution with marine litter.

### 3. Findings and Interpretation

The findings from the monitoring conducted in 2007 – 2021 have revealed 85 per cent of waste found the Primorsky Krai coastal-marine areas have been formed through recreational activities. The morphological composition of the marine litter on the beaches of the areas under study is given in Fig. 4.

**Figure 4.** Morphological composition of marine litter on the Primorsky Krai beaches: left diagram: southern districts; right diagram: north-eastern districts.
Segregation of waste collected as to its composition has provided an opportunity to identify the weight share for each category of waste (plastic, glass, metal, others) in the total weight of the marine litter collected.

It has been found that in the southern coastal territories of the Krai the predominant type of pollution is that with plastic waste and glass waste, while in the northeast – that with the waste falling into the category of "others", the major part of which is represented by rigging materials (ropes, lines, etc.), having significant weight.

The difference is likely to be explained by the prevailing types of anthropogenic activities there: recreational; activities in the South and fishing – in the North-east [6].

Totally, over a 14-year period, more than 2,305 kg (45,700 items) of marine litter have been collected and processed. In the composition of the marine litter it is the packaging materials, mainly plastic, cigarette butts and broken glass fragments that predominate (Fig. 5).

![Figure 5. Total quantity and composition of marine litter collected in Primorsky Krai, 2007-2021.](image)

As evidenced by the figure the prevailing categories of marine litter also relates to the beach recreational activities. The exceptions are the exposed bays of the islands scattered in the Peter the Great Gulf and the NE coast of Primorsky Krai. For instance, on Askold Island (southern Primorye) the marine litter is drifted ashore by the gales and wind. In the hard-to-get bays of the Olginsky district (north-eastern Primorye) the marine litter results from coastal fishing.

The analysis of the monitoring results made it possible to work out a number of recommendations to control the situation with Primorsky Krai coastal-marine areas’ pollution with marine litter, including:

1. Strengthening waste management compliance control on fishing boats, including coastal fishing facilities.
2. Reduction on the use of plastic packaging.
3. Leasing municipal coastal areas out and supervising the sanitary situation in these areas, especially at the end of the recreational season.
4. Environmental issues public awareness raising campaign among all sections of population.

4. Conclusions
Monitoring of marine litter pollution in the coastal-marine zone of Primorsky Krai shows that recreational activities are the predominant sources of waste ingress on the beach. It is household plastic and cigarette butts that prevail in collected waste.

Conducting regular ICC actions allows performing the following functions:
1. Public: environmental issues’ public awareness raising among various sections of the Krai population, development environmental responsibility among citizens.
2. Scientific: a qualitative and quantitative assessment of the pollution of the coastal zone with litter, determining the trends and patterns of its distribution.
3. Administrative: making managerial decisions in the field of waste management, planning control and supervisory activities.

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