

Plastisphere microbiome: Methodology, diversity, and functionality

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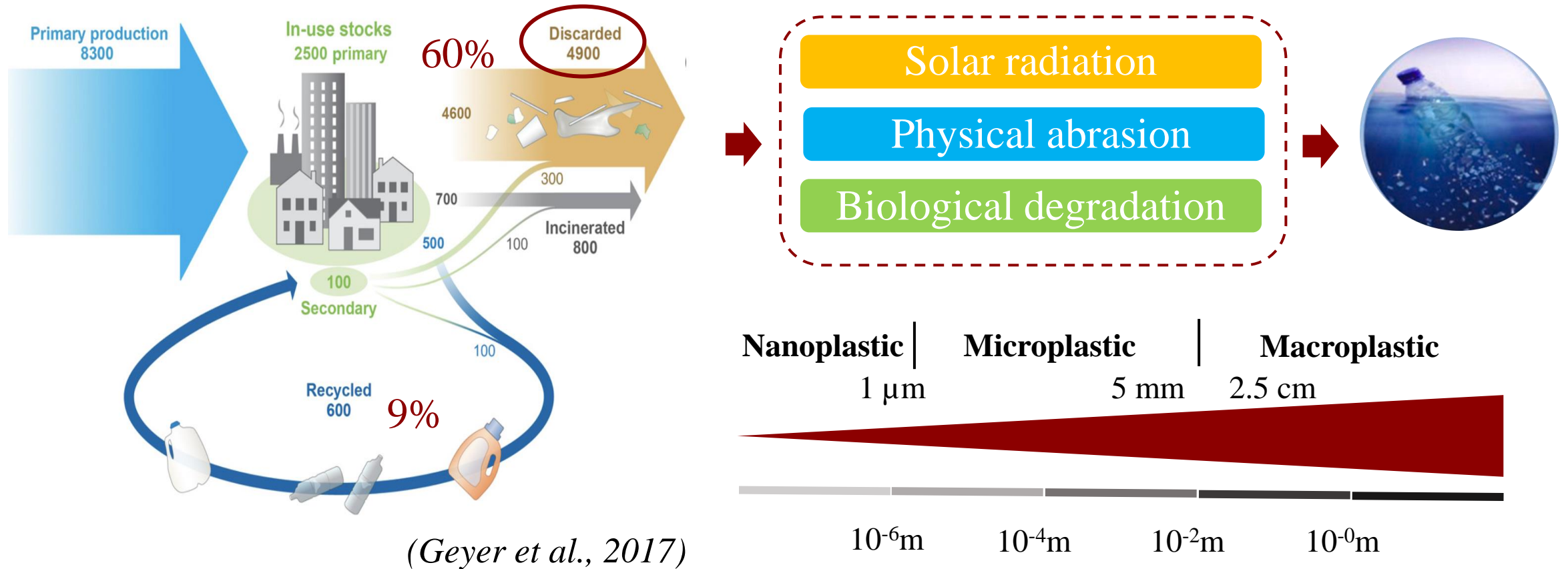
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Introduction

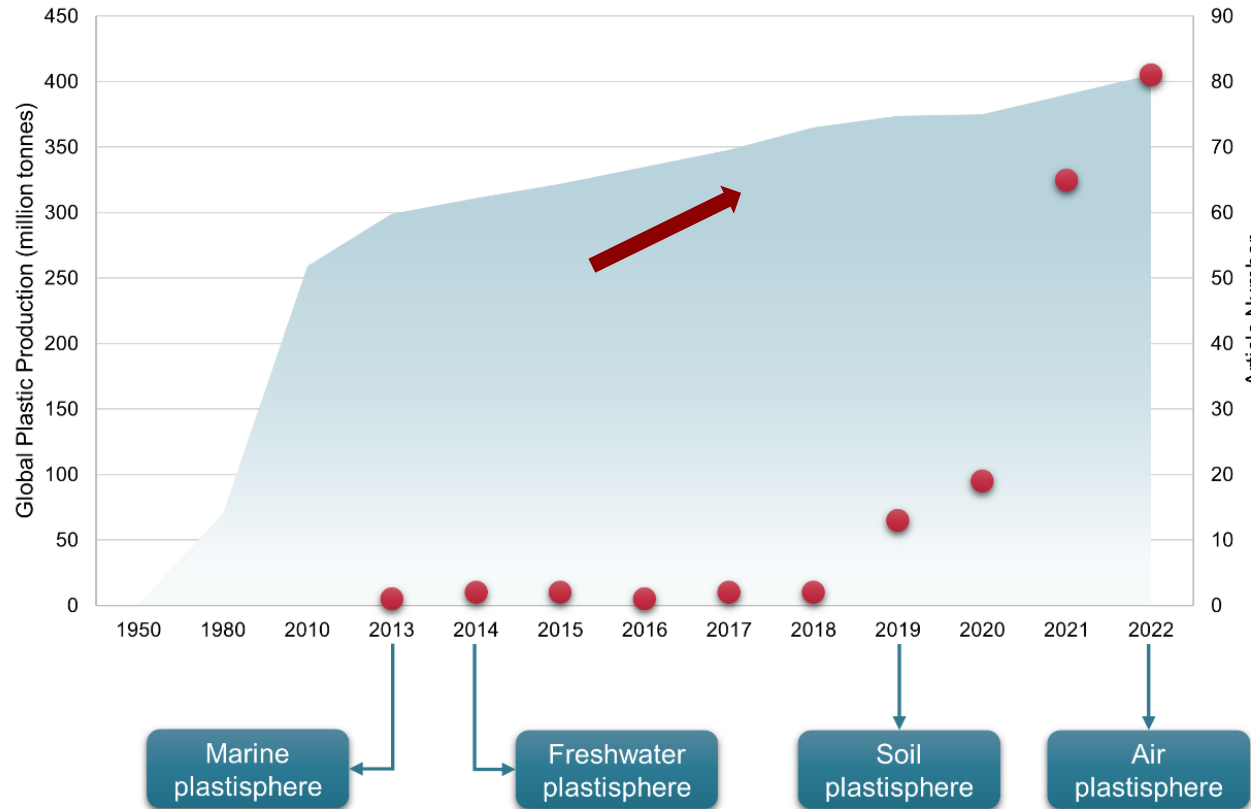
Plastic waste and the formation of microplastics (MPs)



- Approximately 12,000 metric tonnes of plastic waste will be accumulated globally by 2050.
- MPs can be ingested and transmitted to higher trophic-level organisms through the food chain, and thus harm biodiversity and ecosystems.

Plastisphere studies: from marine to land

- A unique and distinct niche for the growth and proliferation of a diversity of microorganisms.



- Dr. Erik Zettler and colleagues first established the concept of the “plastisphere” in 2013.
- From marine environments to freshwater ecosystems, terrestrial habitats, and other artificial environments.

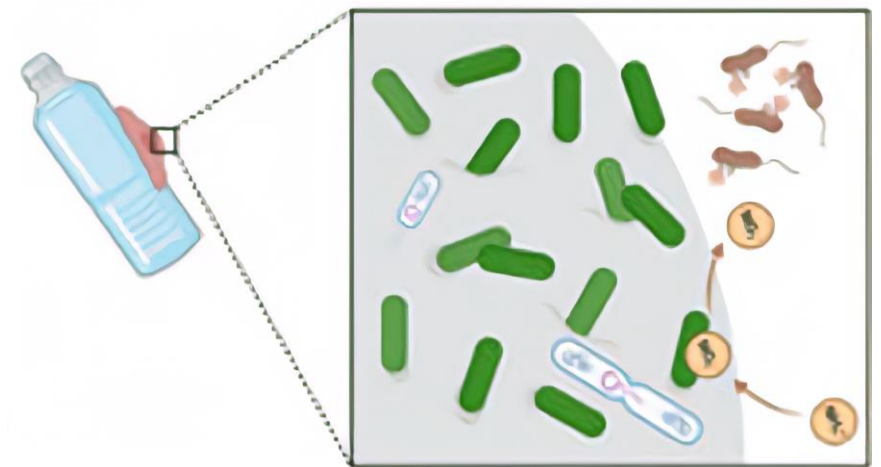


Figure 1. A timeline of plastic production and plastisphere study.

Experimental methods for studying plastisphere

Sample collection

- Field sampling
- In situ field culture
- Laboratory-simulated experimentation

Method	Advantage	Disadvantage
Field sampling	Reveal the realistic characteristics	Difficult to identify polymer types
In situ culture	Freely use polymers	Hard to quantify the effects of environmental factors Introduce heterogeneity
Laboratory simulation	Evaluate environmental variables	Hard to simulate field conditions

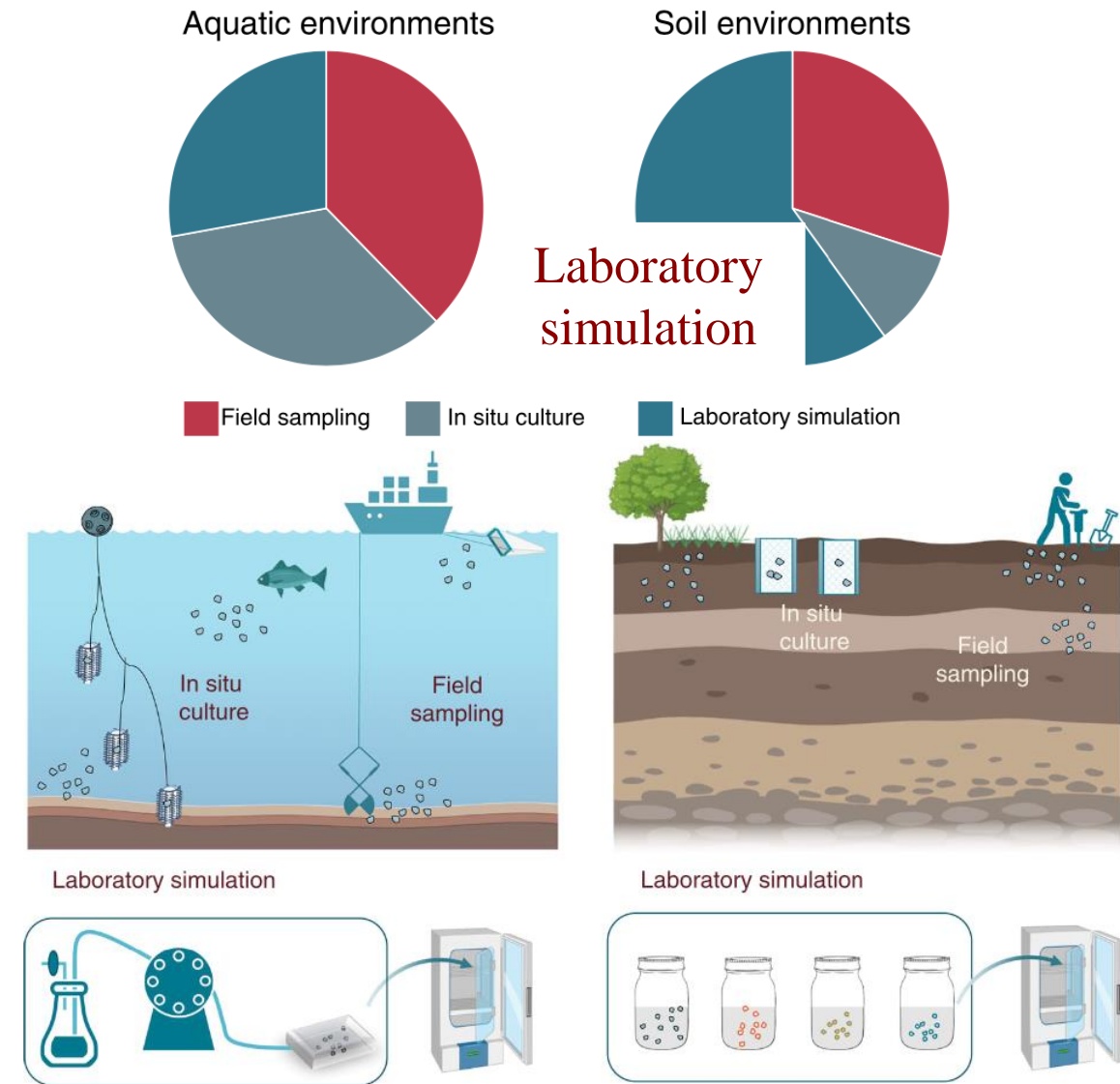


Figure 2. The typical experimental approaches to study plastisphere in aquatic and terrestrial environments.

Characterization methods: from amplicon sequencing to omics research

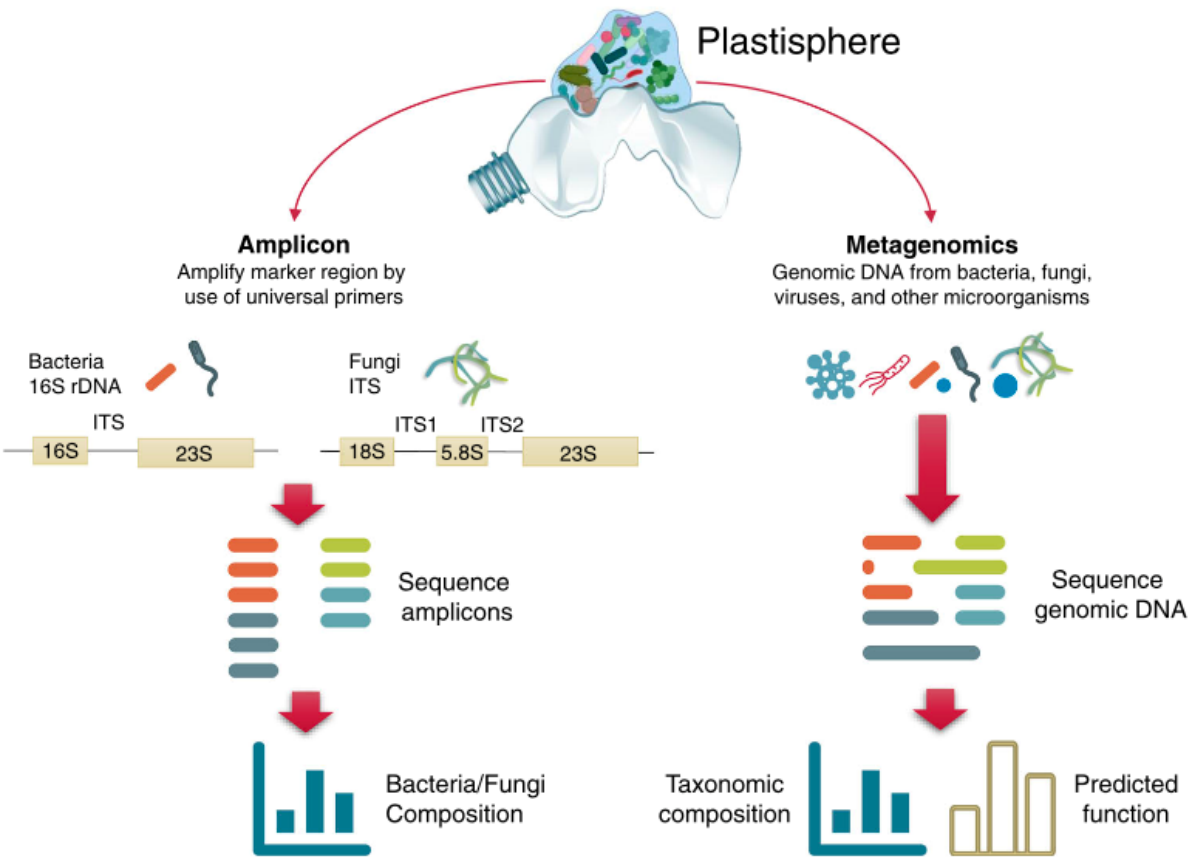


Figure 3. Amplicon and shotgun metagenomic sequencing used for studying plastisphere.

Imaging technologies

- Scanning electron micro-copy (SEM)
- Combinatorial labeling and spectral imaging-fluorescence in situ hybridization (CLASI- FISH)

Next-generation sequencing (NGS) technologies

- Amplicon sequencing (16S, 18S, ITS)

Long-read sequencing technologies

- Third-generation Pacific Biosystems SMRT
- Oxford Nanopore sequencing

Multimomics

- Shotgun metagenomic sequencing
- Metatranscriptomic
- Proteogenomic
- Metabolomic

The composition and assembly of the plastisphere

Composition

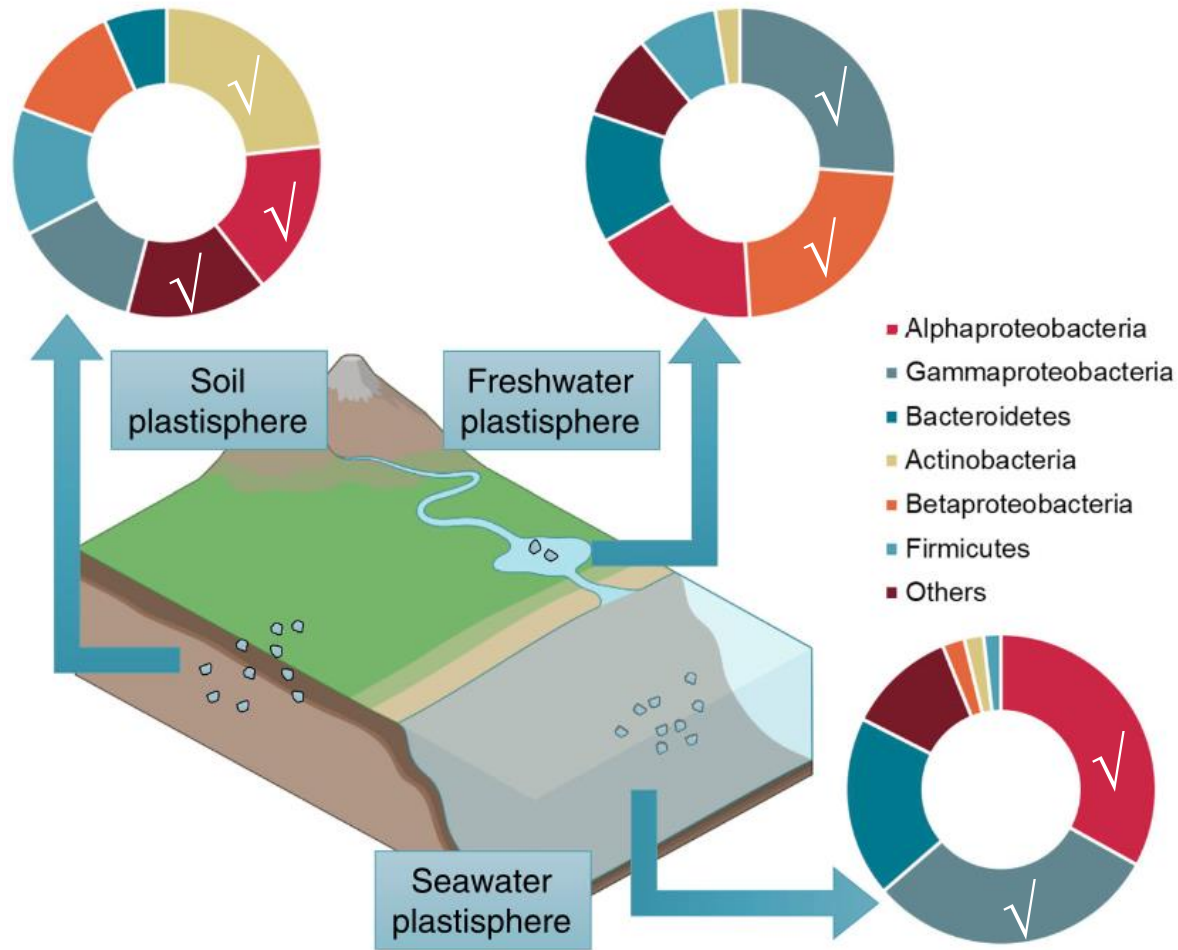


Figure 3. General structure of the bacterial communities in seawater, freshwater, and soil plastisphere

Assembly

Ecological mechanisms

- Niche-based theory
- Neutral theory

Ecological and evolutionary processes

- Selection
- Dispersal
- Drift
- Diversification

Influencing factors

- The stage of colonization (selection → dispersal/drift)
- MPs properties
- MPs-leached compounds
- Location-specific properties

The functions of plastisphere

Microplastics degradation

- Hydrocarbon-degrading bacteria
- Putative xenobiotic biodegradation genes
- PET-degrading enzymes

Elemental geochemical cycles

- Adenylyl sulfate reductase and dissimilatory sulfite reductase genes
- *nifH*
- Sulfur reduction



Pathogens and antibiotic resistance genes (ARGs)

- *Vibrio* species
- Greater the abundance and diversity of ARGs
- Promote horizontal gene transfer

Perspective

- Detailed information on microbial community succession
- The key factors influencing the plastisphere communities
- More attention on fungal and other micro-eukaryotic communities
- Comprehensive methods for an in-depth understanding

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