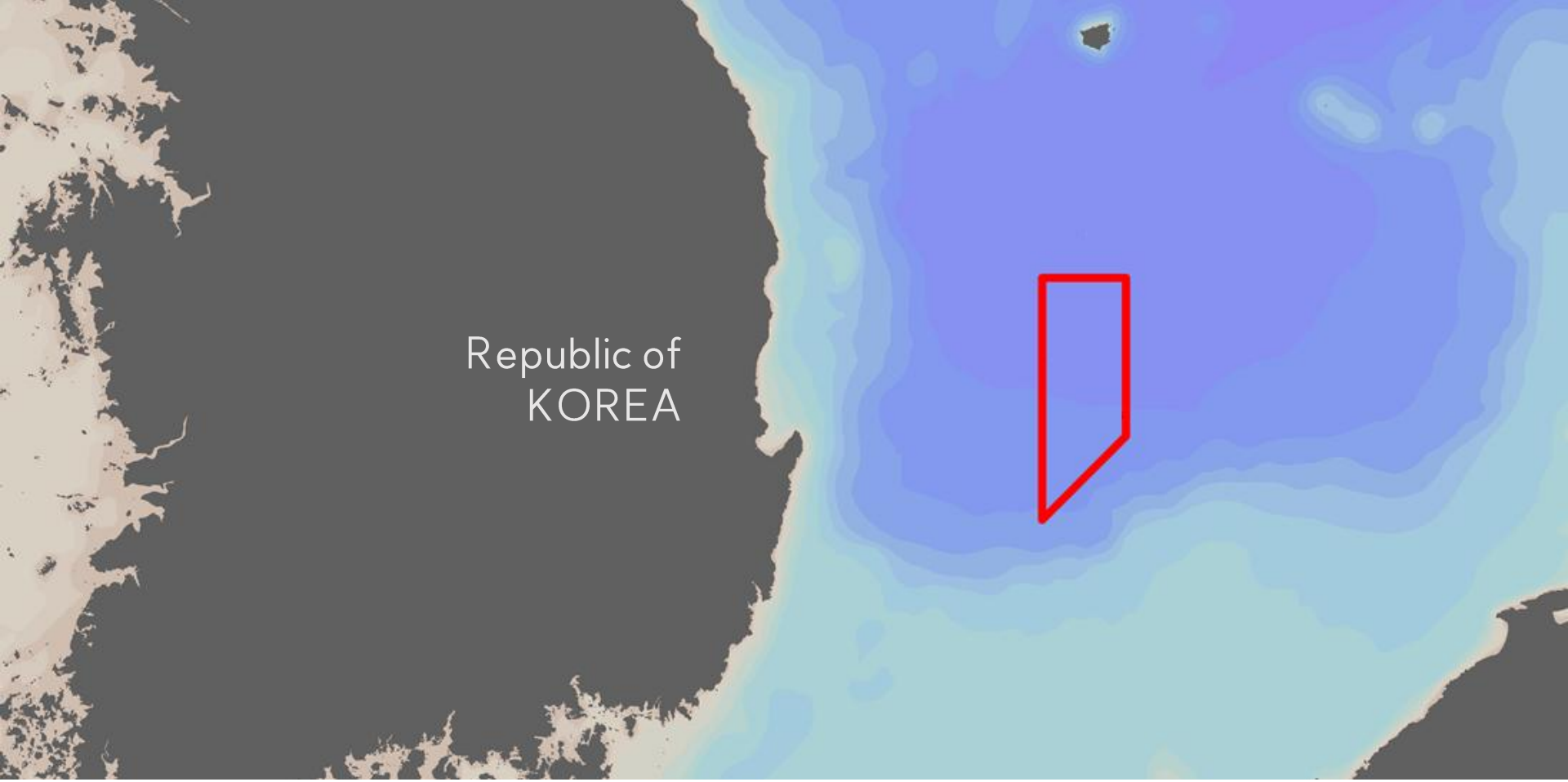


Ministry of Oceans and Fisheries

KIOST
한국해양과학기술원
KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

LC/SG 48/17

2025 Science Day

The Monitoring and Management of Disposal Sites

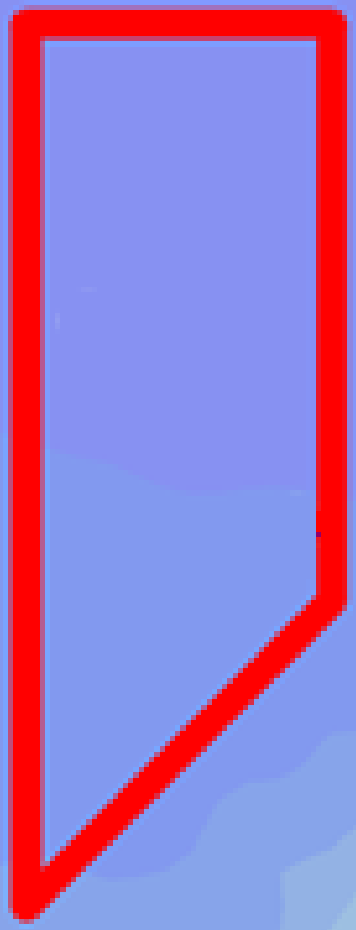
Republic of KOREA

Regional Background Levels:

A Practical Approach to Monitoring and Managing Heavy Metal Contamination at Ocean Disposal Sites

Korea Institute
of Ocean Science & Technology

Kim C J

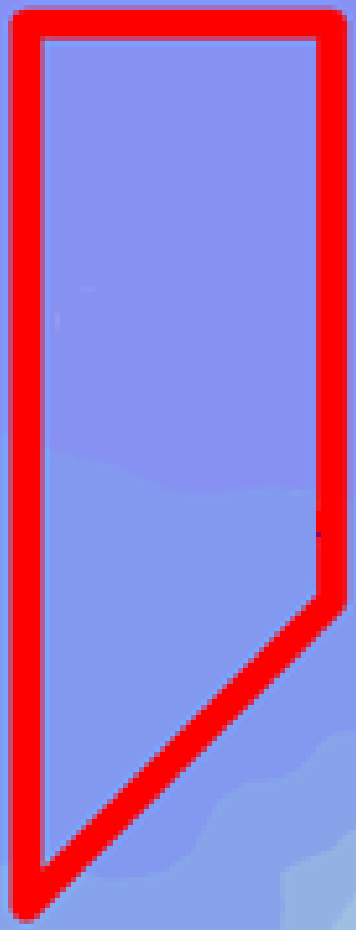


ES-B
Ocean Dumping Site

2,200 m

1,800 m

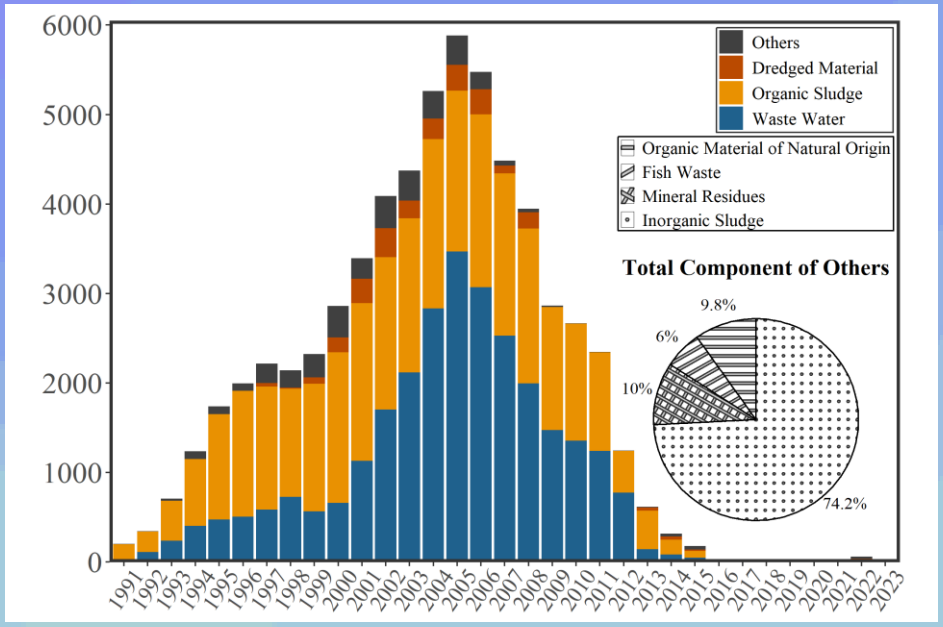
1,600 m

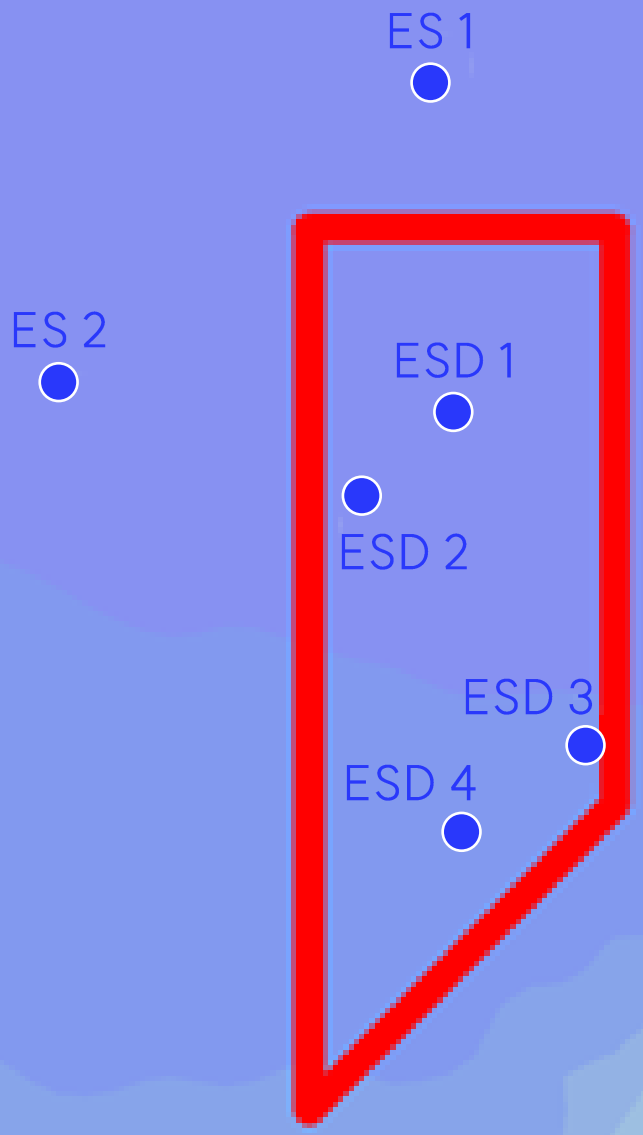


ES-B
Ocean Dumping Site

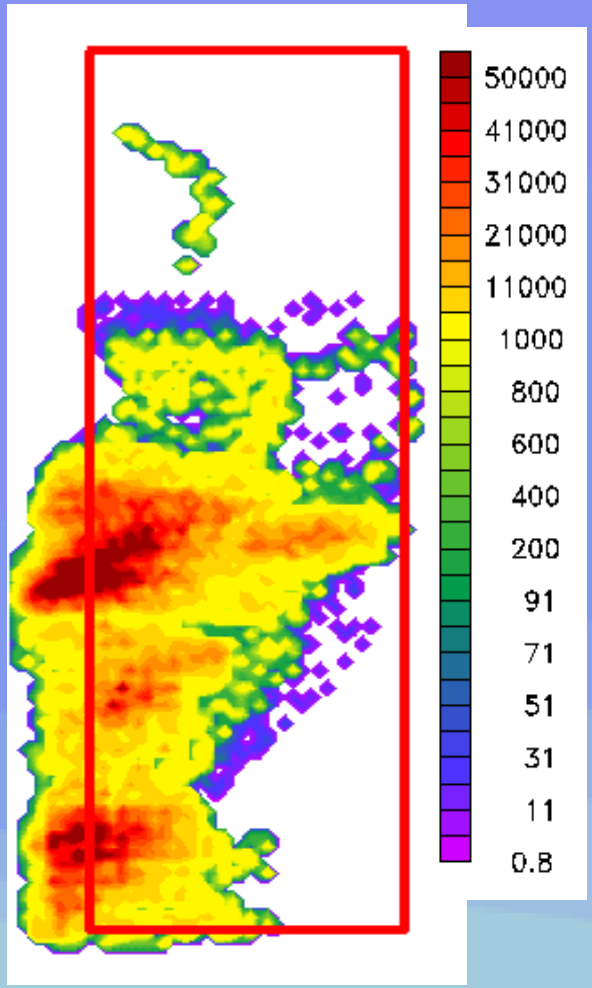
From 1991 to 2023,

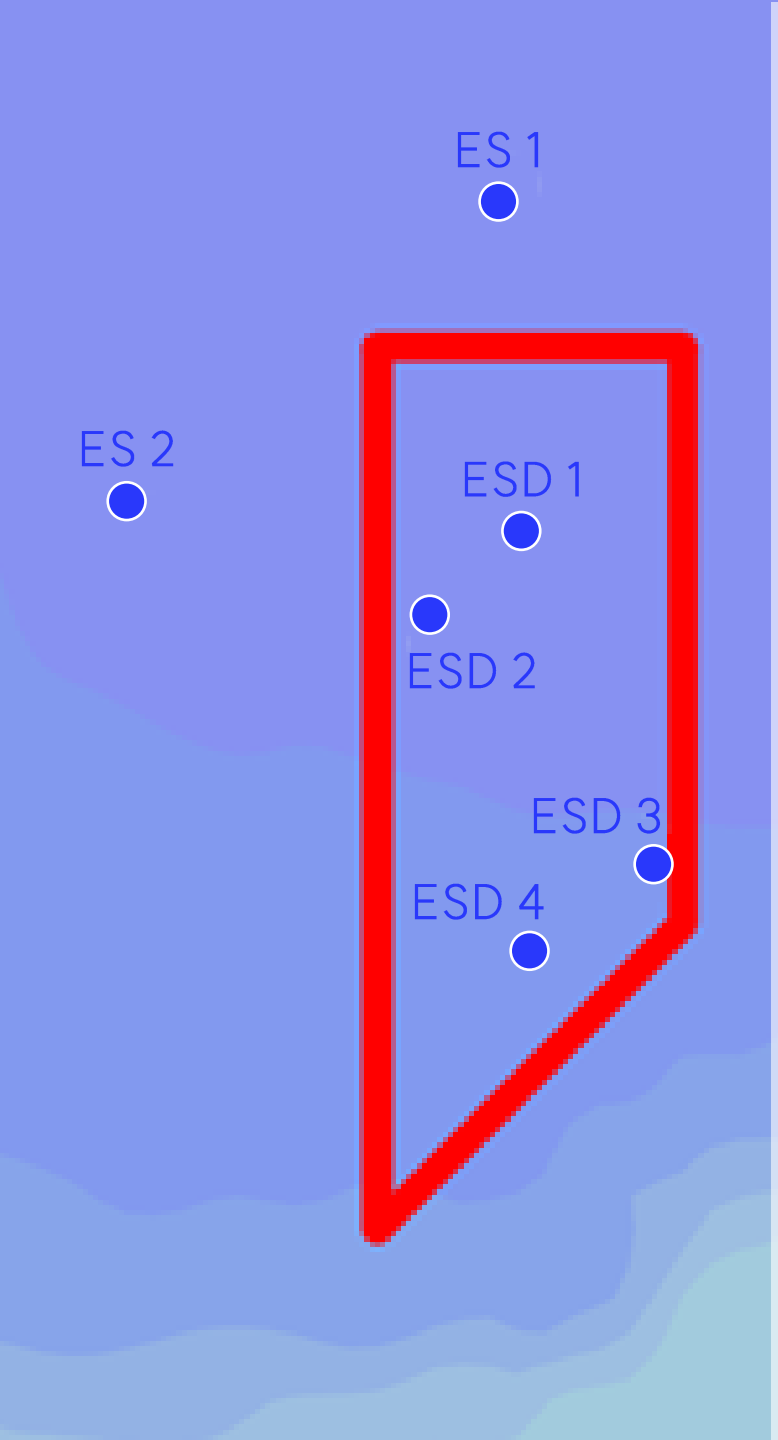
Total 63,000 m^3 were dumped





Modeled distribution of seabed organic sludge based on the frequency of dumping activities at ES-B ocean dumping site (1992~2005)

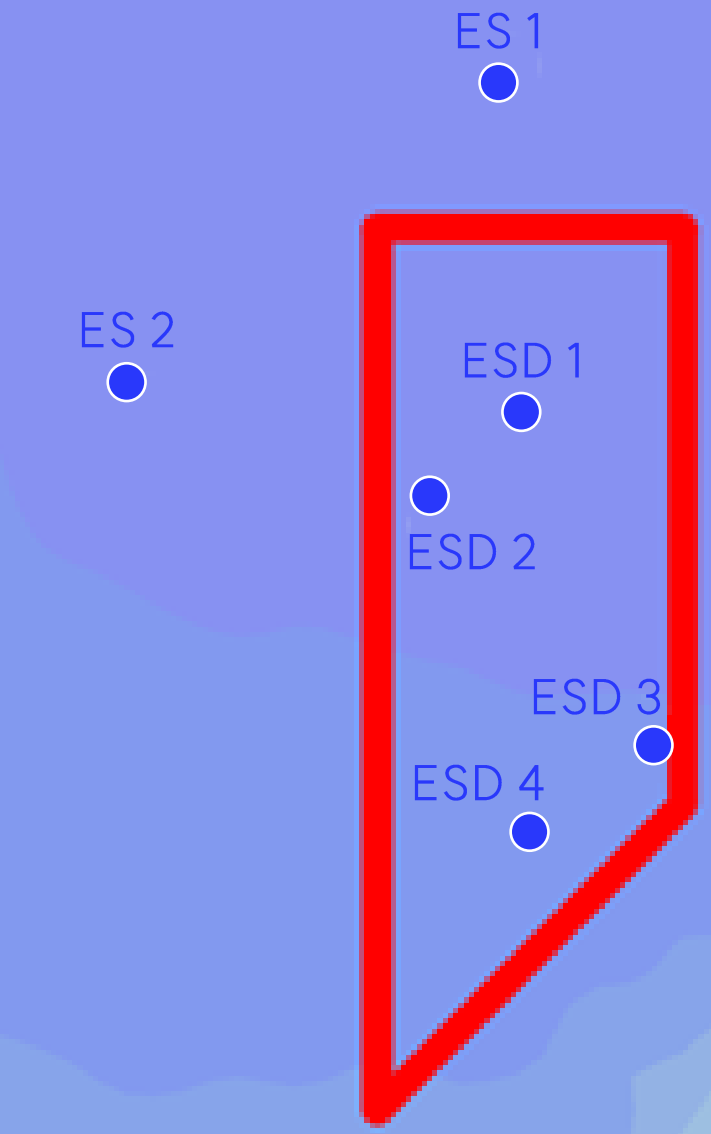


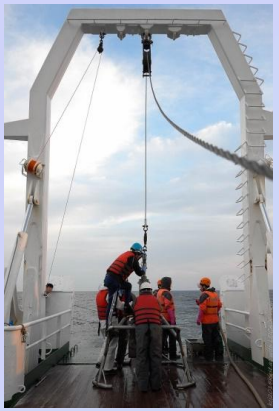


Field Sampling

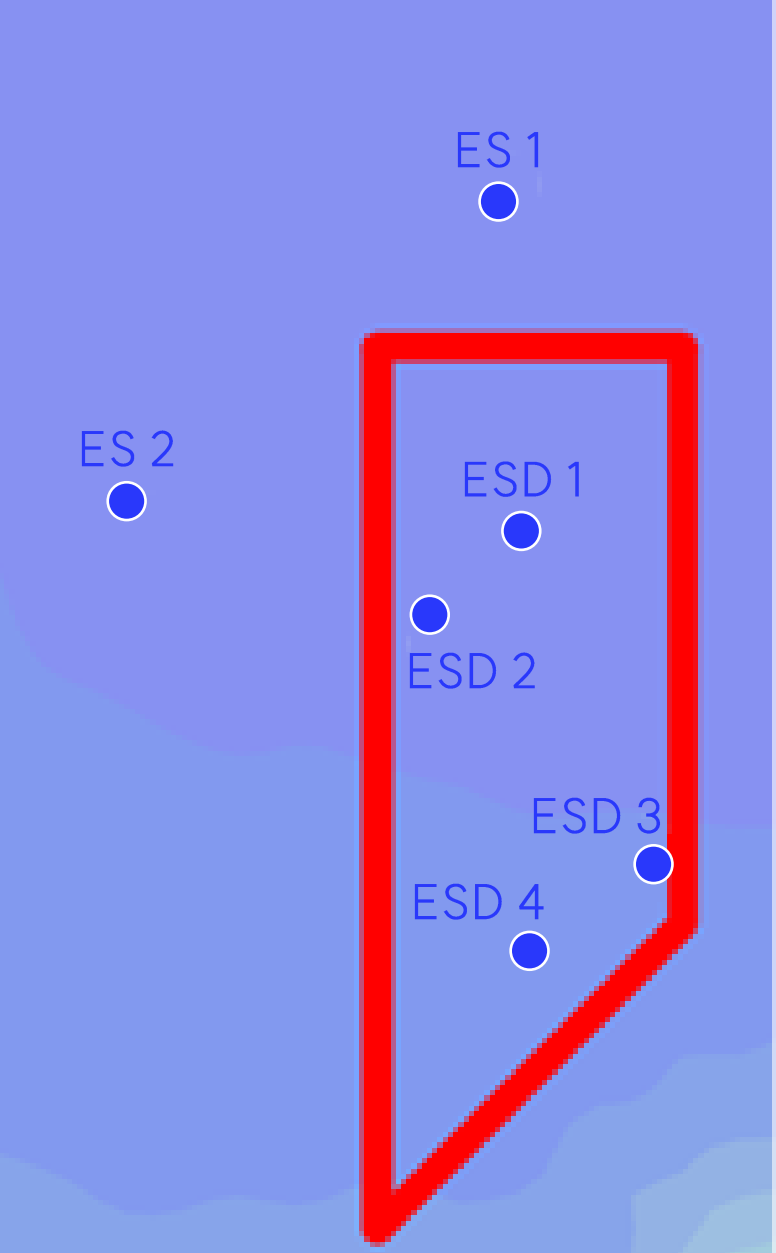
- 2018 ~ 2022
- The R/V ONNURI (1,500 t) of KIOST
- Study Stations
  4 dumping stations: ESD 1, 2, 3, 4
  2 reference stations: ES 1, 2
- Box core Sampler
  400 x 400 x 600 mm

Field Sampling



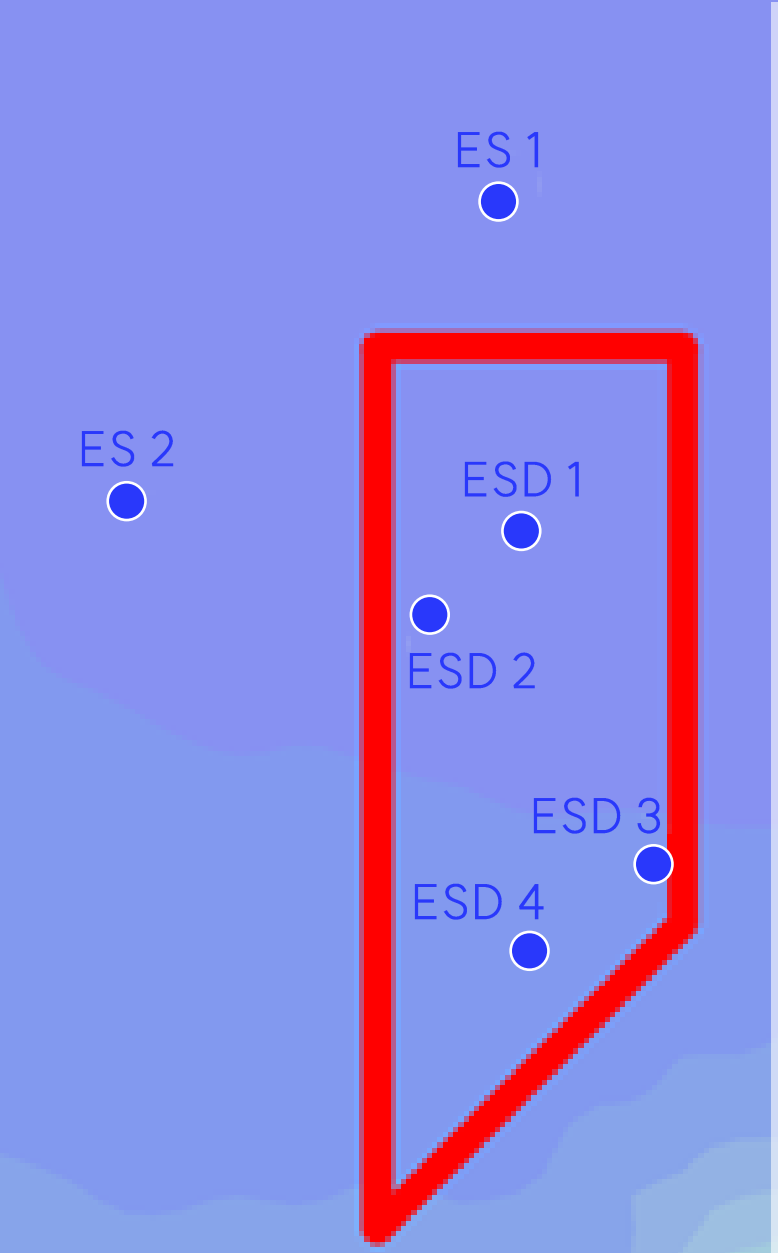


Core Sample



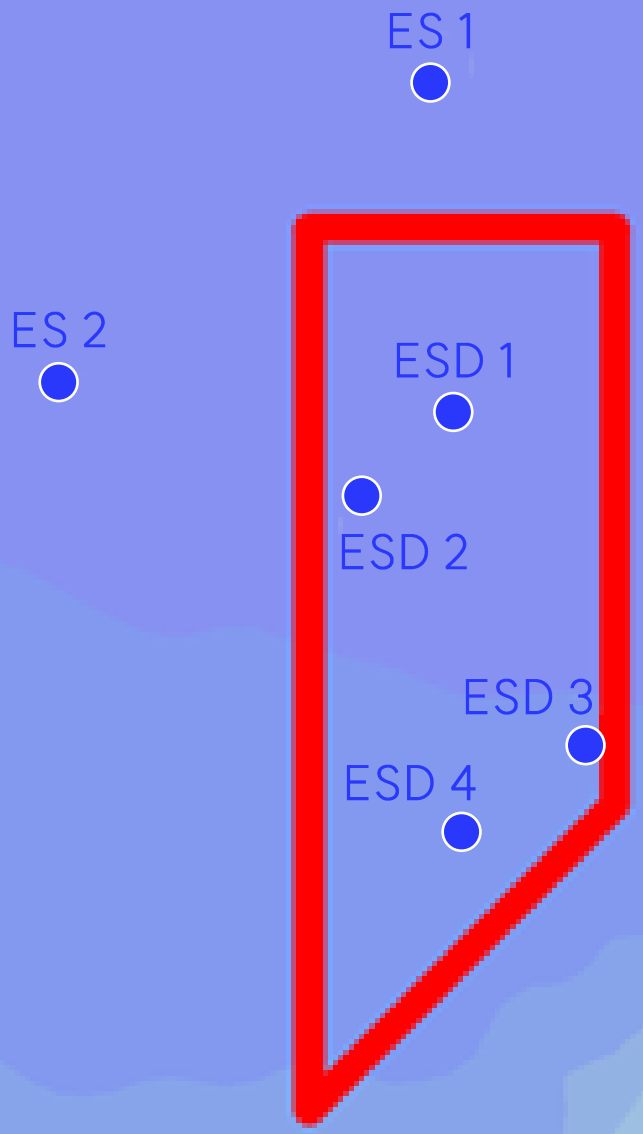
Heavy Metal Analysis

- Surface/Core Sediments
- A single core sample was precisely sectioned into **1 cm thick layers** from the surface to the bottom
- 7 Heavy Metals:
  Cr, **Co**, **Cu**, **Zn**, **Cd**, **Hg**, and **Pb**
- **Acid total digestion** methods
- Inductively coupled plasma mass spectrometer (ICP-MS)



Sediment Chronology

- **Sedimentation rates** were estimated by **measuring the decay of natural lead-210** (^{210}Pb)
- 0.1 ~0.2 cm/yr at the Study Site
- **Consequently,** a **30cm** core sample covered the periods from 1700s to 2022



Sediment Chronology

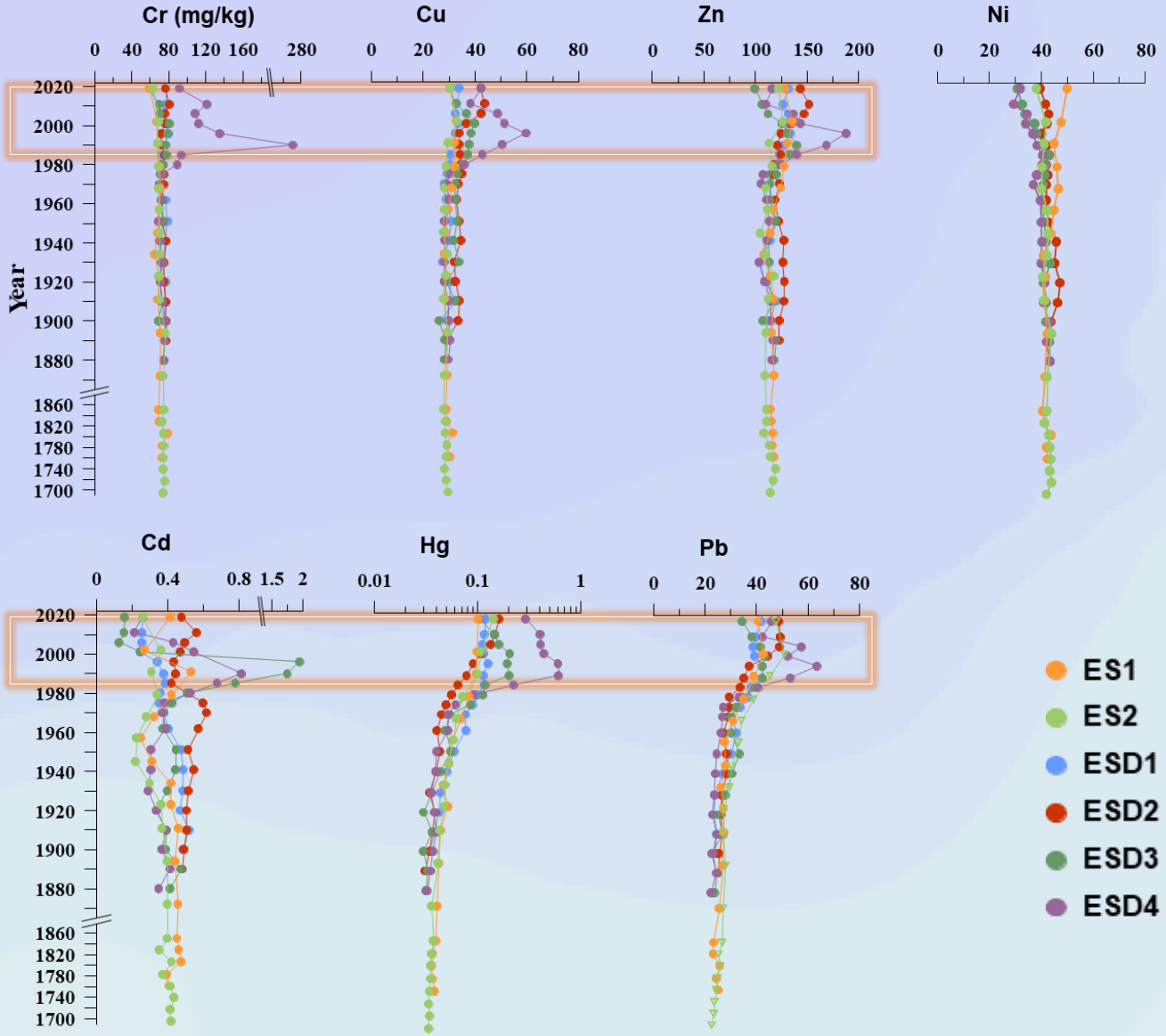
- In the Rep. of KOREA,
  Ocean dumping was started **in 1988**

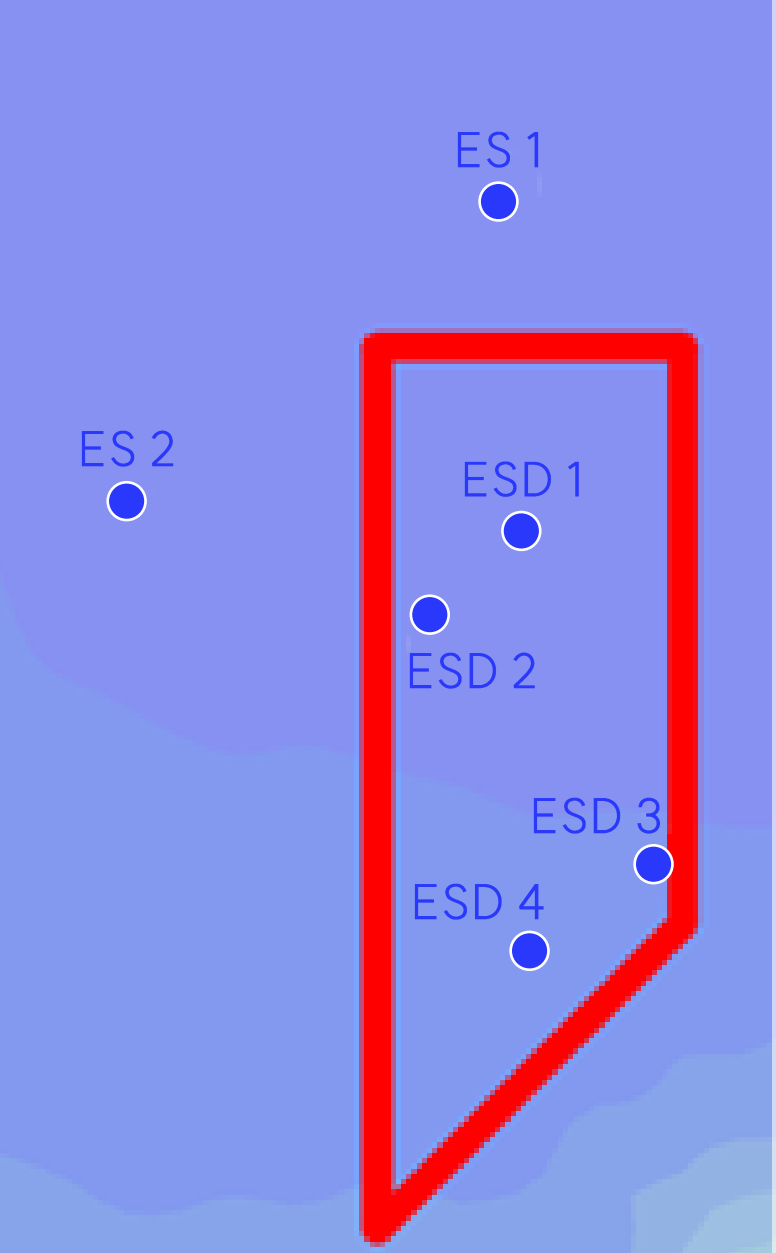
0~6 cm: **Post-1980s**
(Dumping-Affected)

6~30 cm: **Pre-1980s**
(Pre-dumping)

Core Sample

Vertical Profiles of 7 Heavy Metals





Sediment Quality Guidelines (SQGs) of Rep. Korea

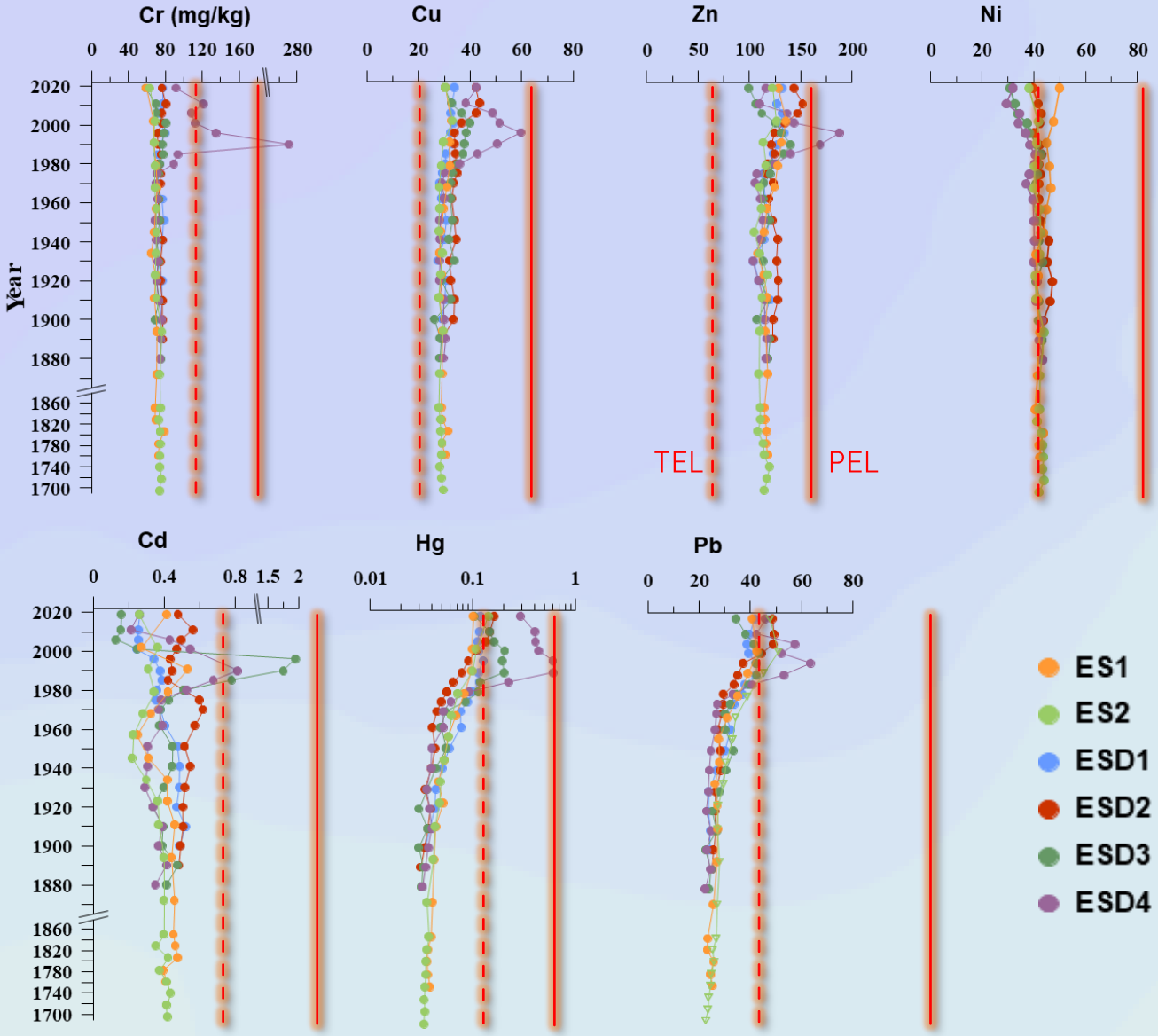
- Threshold Effect Level (TELs):
  Concentrations at which
  adverse effects on ecosystems rarely occur
- Probable Effect Levels (PELs):
  Concentrations that are
  associated with a high probability of adverse effects
  on ecosystems

SQGs for Heavy Metals
in the marine Sediment
In KOREA:

Action Lists & Action Levels

(mg/kg)	TEL	PEL
Cr	116	181
Ni	41.2	80.5
Cu	20.6	64.4
Zn	68.4	157
Cd	0.75	2.72
Hg	0.11	0.62
Pb	44.0	119

Sediment Quality Guidelines (SQGs) of Rep. Korea



(mg/kg)	TEL	PEL
Cr	116	181
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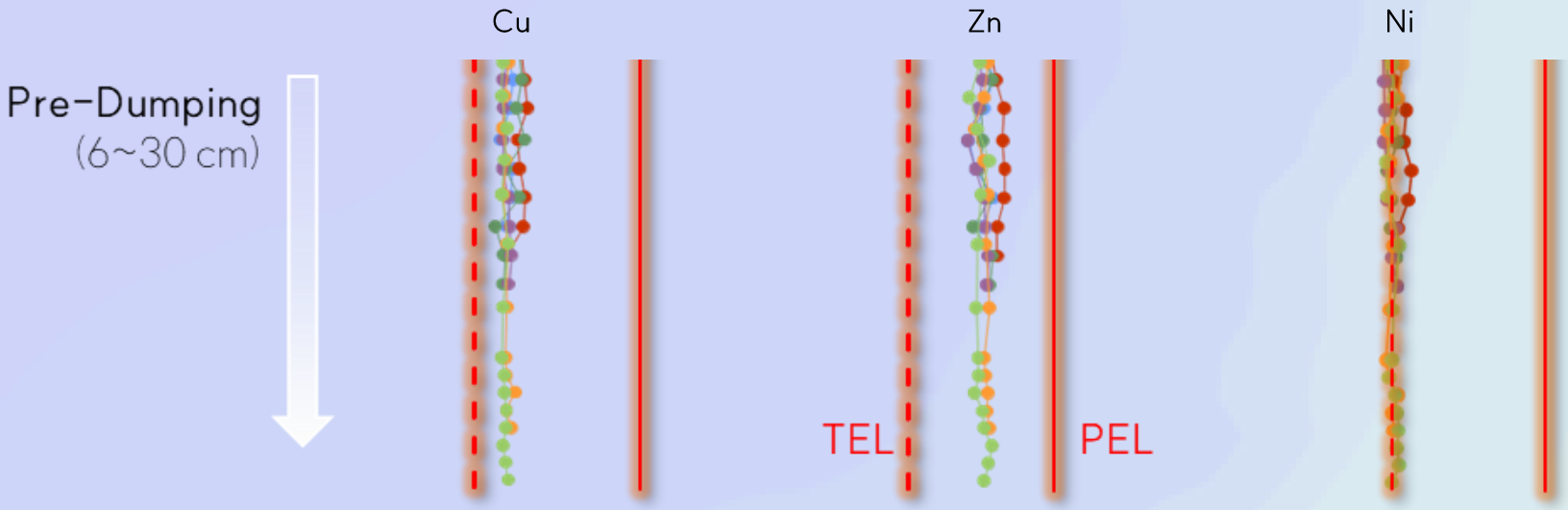
Regional Background Concentrations (RBCs)



Therefore, **RBCs** are Essential!

- **TELs & PELs Criteria** are derived from a comprehensive review of coastal sediment studies.
- **Coastal vs. Deep-sea** sediments exhibit distinct input factors and transformation patterns, respectively.
- Thus, to ensure robust and precise pollution assessments, **Deep-Sea-Specific Standards** are imperative.

How Were **RBCs** Established in This Study?

Step 1. Core Sample Collection

- ✓ Samples were collected at the study site aboard R/V Onnuri

Step 2. Chemical Analysis & Result Validation

- ✓ Heavy metals & key parameters (e.g., TOCs, Particle size) were analyzed
- ✓ Data were validated for consistency and accuracy

Step 3. Determining Pre-Dumping Metal Concentrations

- ✓ Sedimentation rates (Lead-210) defined depth thresholds to separate pre-dumping sediments (below 10 cm) from those affected by marine dumping
- ✓ Average metal contents from sediments dated before 1900 were used to derive RBCs

Step 4. Confirming Sedimentary Uniformity

- ✓ Minimal vertical variability in heavy metal levels (including Al and TOCs) confirms uniform particle size and mineral composition across the study area

Derived RBC Values for Heavy Metals at Study Site

Cr	Ni	Cu	Zn	Cd	Hg	Pb
(mg/kg)						
74	43	29	115	0.4	0.03	24

RBCs VS. Upper Continental Crust (UCC) Values

(mg/kg)	Cr	Ni	Cu	Zn	Cd	Hg	Pb	Reference
UCC_1	35	20	25	71	0.098	0.04	20	Tayloer & McLennan, 1995
UCC_2	92	47	28	67	0.09	0.05	17	Rudnick et al., 2003

- UCC provides a baseline value
  based on the average elemental makeup of the Earth's upper crust.
- Traditional deep-sea pollution assessments have predominantly relied on UCC reference values.
- However, they do not reflect region-specific compositional characteristics!

RBCs VS. Upper Continental Crust (UCC) Values

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UCC_2	92	47	28	67	0.09	0.05	17	Rudnick et al., 2003
RBCs	74	43	29	115	0.4	0.03	24	This study

RBCs-Based Contamination Evaluation at Study Site

Key Contamination Evaluation Indices

- Enrichment Factor (EF):
  - ✓ Compares metal contents in samples to background levels using a reference element.
- Pollution Load Index (PLI):
  - ✓ Aggregates CFs of multiple metals to provide an overall pollution score.
  - ✓ CF: Contamination factor, ratio of measured pollutant contents to a baseline value

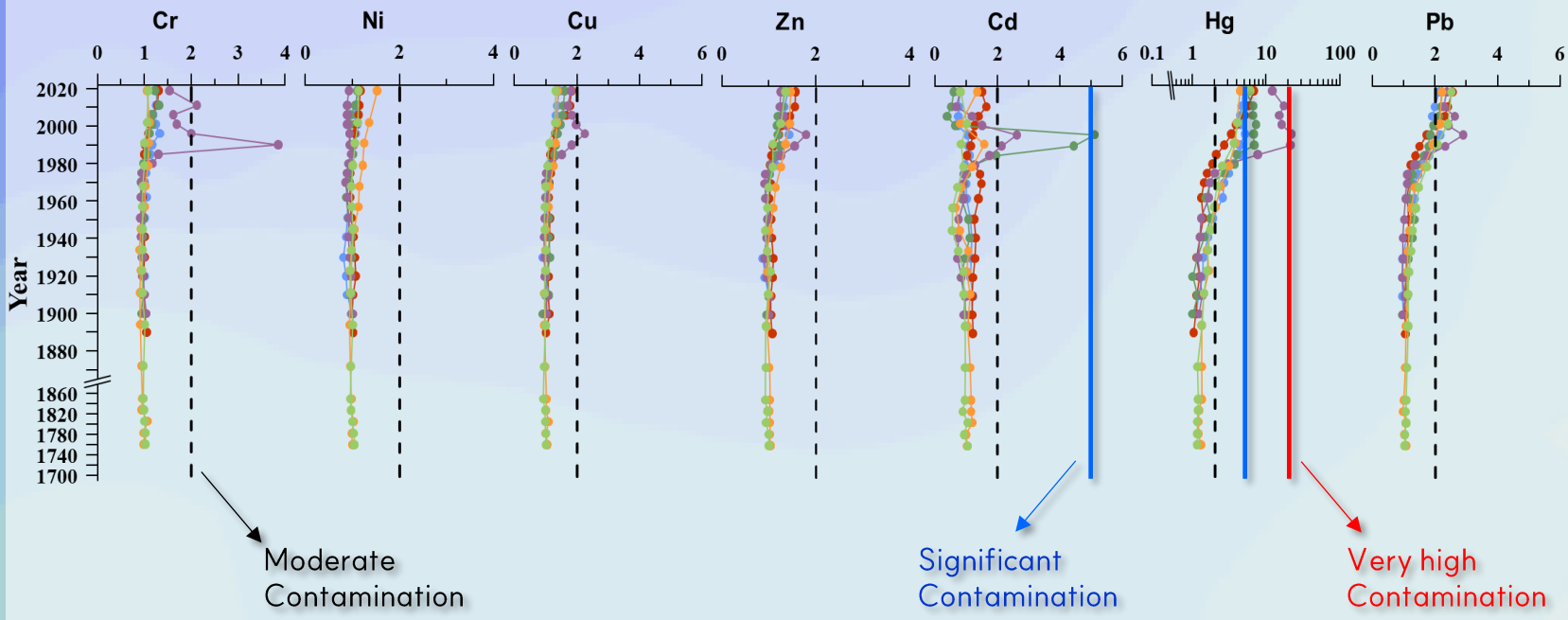
Index	Meaning	Key Value	
		Range	Contamination Level
EF	Measures metal enrichment vs. natural levels	2-5 5-20 20-40	Moderate Significant Very high
PLI	Measures overall pollution from multiple metals	1-2 2-3 >3	Moderate High Extremely high

RBCs-Based Contamination Evaluation at Study Site

Index	Metal	**RBCs**	UCC_1	UCC_2
EF	Cr	0.9–3.9	1.9–8.0	1.4–5.8
	Ni	0.8–1.5	1.7–3.2	1.4–2.6
	Cu	0.9–2.3	1.0–2.6	1.8–4.4
	Zn	0.9–1.8	1.4–2.8	2.8–5.8
	Cd	0.4–5.1	1.6–20	3.3–42
	Hg	1.0–22	0.7–16	1.1–25
	Pb	0.9–2.9	1.1–3.4	2.5–7.7

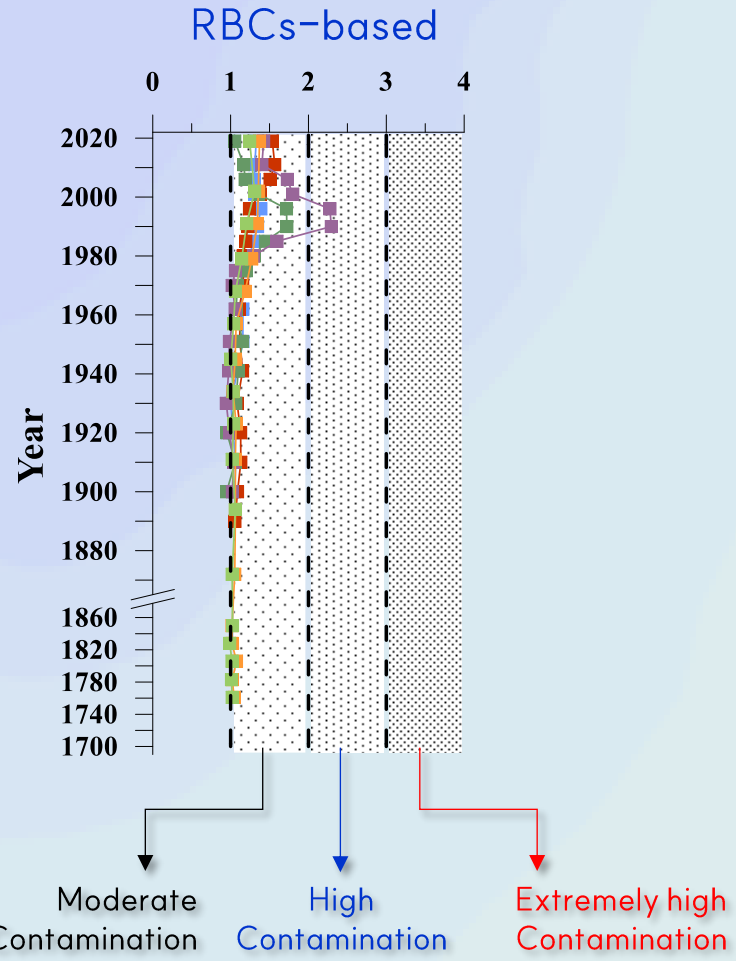
Significant Contamination

Very high Contamination



RBCs-Based Contamination Evaluation at Study Site

Index	**RBCs**	UCC_1	UCC_2
PLI	0.9–2.3	1.5–3.7	1.1–2.7



Summary

- Current Practice:
  - ✓ Korea currently manages deep-sea dumping sites using **SQG**s based on **TEL/PEL** criteria.
- Limitation of Existing Guidelines:
  - ✓ However, these guidelines—derived from coastal sediment studies—aren't ideal for **deep-sea sediments**.
- Our Approach:
  - ✓ So, we derived **RBCs** for 7 heavy metals from core samples for a more accurate assessment.
- Evaluation Results:
  - ✓ Our RBC-based evaluation shows **moderate contamination overall** – with some hotspots at high levels—while **UCC-based methods tend to overestimate** pollution.
- Implications & Recommendations:
  - ✓ This RBC-based approach offers a **more realistic baseline** and can improve national guidelines and management strategies for **dumping site pollution**.

This presentation is based on our 2024 Marine Pollution Bulletin submission.

Marine Pollution Bulletin 200 (2024) 116065

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Applying new regional background concentration criteria to assess heavy metal contamination in deep-sea sediments at an ocean dumping site, Republic of Korea

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ARTICLE INFO

Keywords:
Heavy metals
Sediments
Regional background concentrations
Ocean dumping site
East Sea

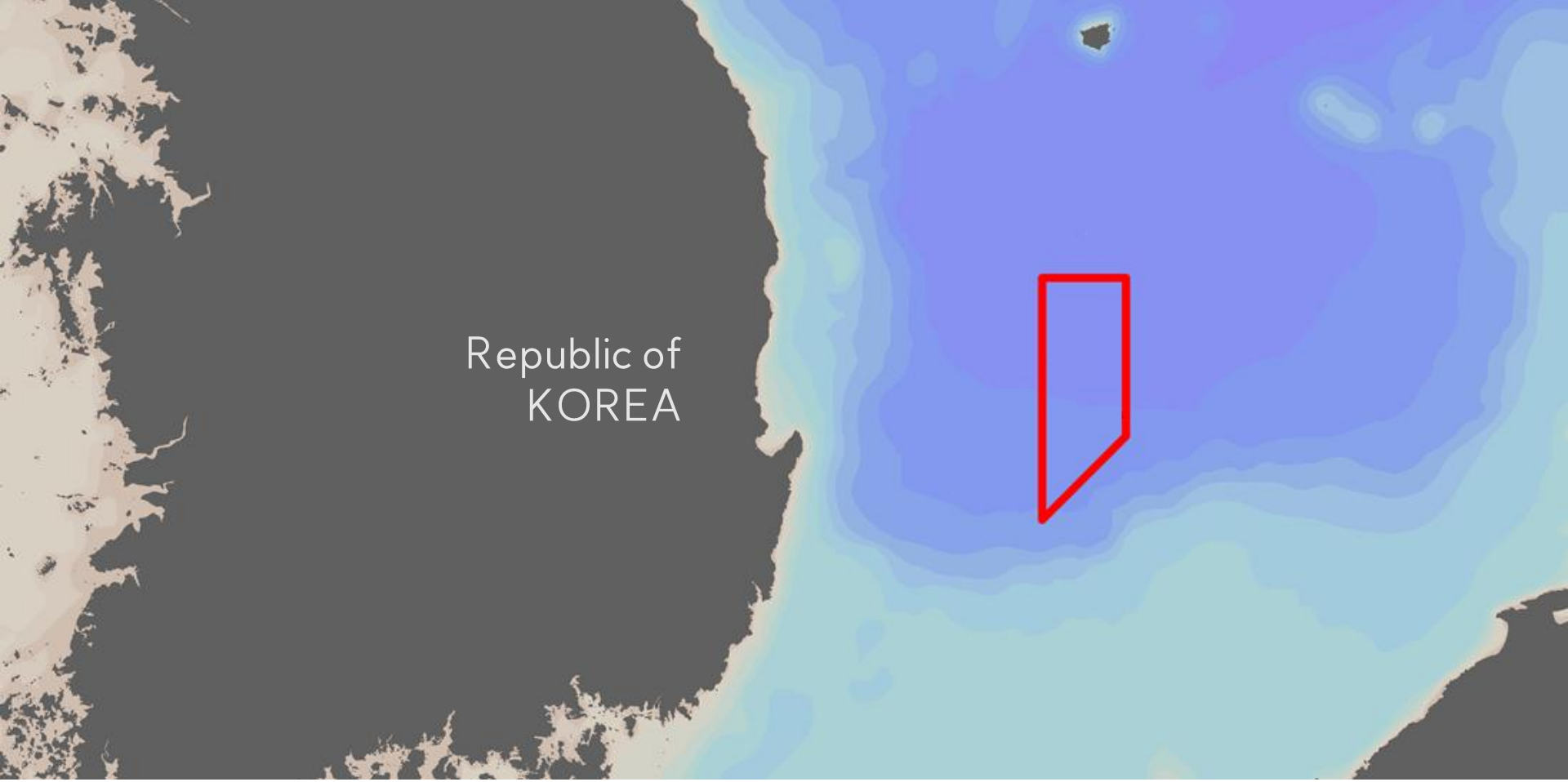
ABSTRACT

It is crucial to establish appropriate background concentrations to discern heavy metal pollution in the marine environment. In this study, we analyzed heavy metals in deep-sea sediment cores to determine regional background concentrations at the East-Sea Byeong Ocean dumping site. The vertical profiles of heavy metals were categorized into three groups based on their contamination characteristics, and regional background levels for 12 metals were determined using pre-1900 averages. The enrichment factor, contamination factor, and pollution load index, calculated using regional background concentrations, indicated significant contamination by Cr, Co, Cu, Zn, Cd, Hg, and Pb during the ocean dumping period. These results differ from those obtained using global average concentrations. This underscores the importance of considering regional characteristics to minimize the risk of misinterpreting anthropogenic impacts. The approach based on local information is considered useful when sediment quality guidelines are absent or inapplicable.

1. Introduction

Heavy metals are toxic, environmentally persistent, and their bio-

and Kleemola-Juntunen, 2018). Currently, there are 87 parties to the London Convention and 54 to the London Protocol. These parties are obligated to submit reports on the comprehensive management of ocean



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