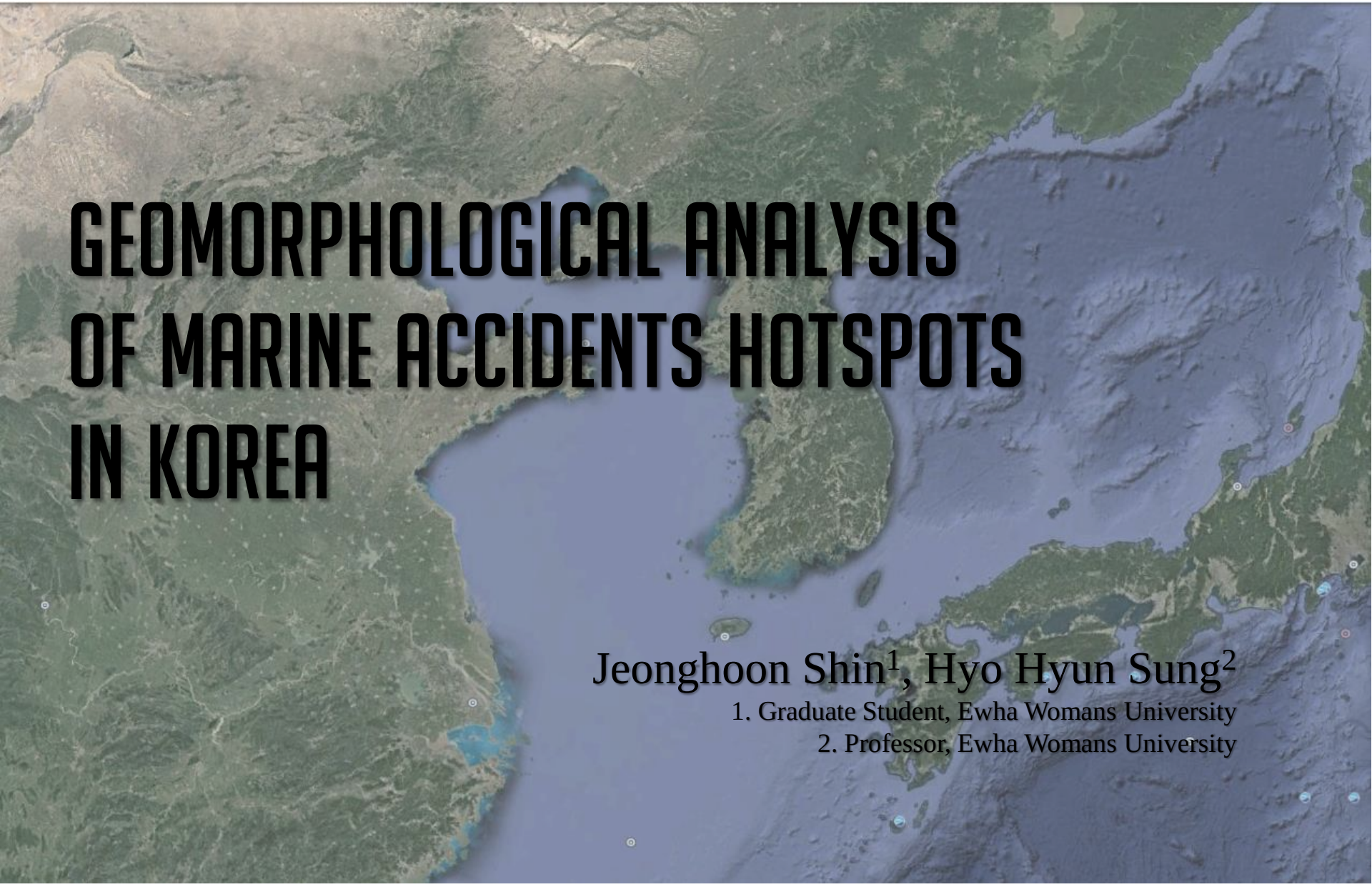


# GEOMORPHOLOGICAL ANALYSIS OF MARINE ACCIDENTS HOTSPOTS IN KOREA

Jeonghoon Shin[1], Hyo Hyun Sung[2]
1. Graduate Student, Ewha Womans University
2. Professor, Ewha Womans University

# CONTENT

1. Research Background and Research Objective
2. Data and Methodology
3. Patterns of the Marine Accidents Occurred in Korea
4. Geomorphological Characteristics of the Hotspots of the Marine Accidents
5. Conclusion

# 1.1 Research Background

- Marine accident means all types of accident happened on the sea surface.
- In Korea, the number of the marine accidents has consistently been increased since 1980
- It multiplies nearly tenfold from 1980 to 2016

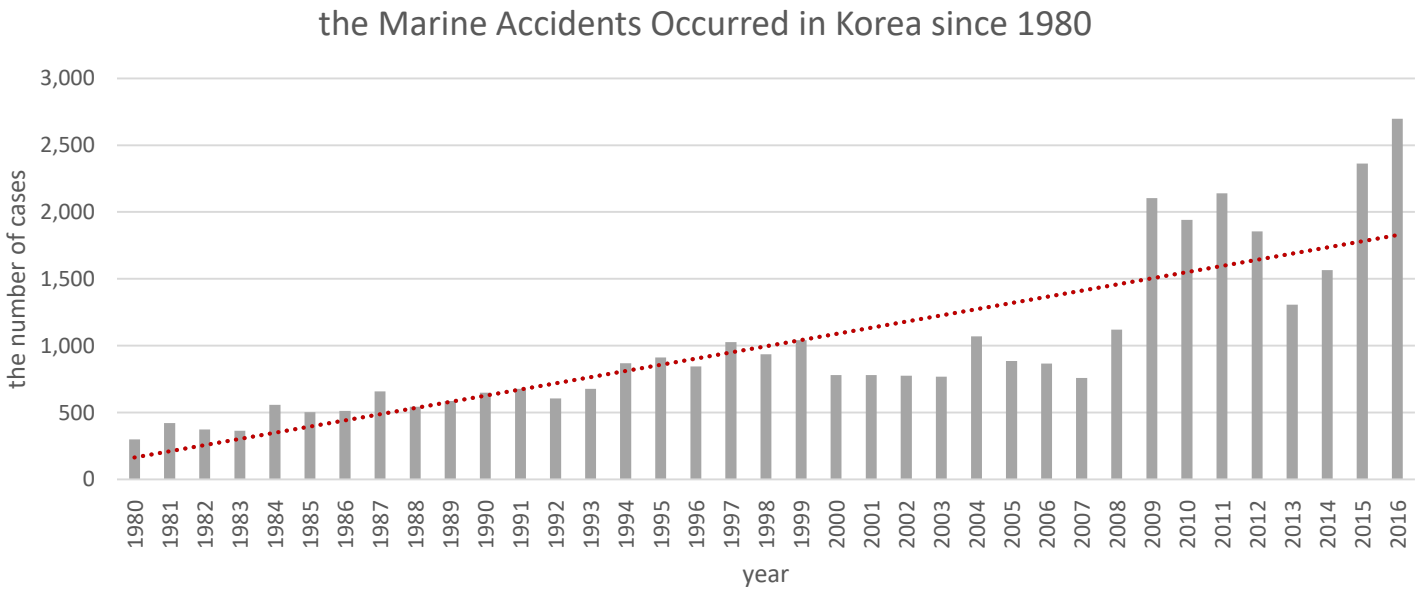



Figure 1 Marine Accidents Occurred in Korea since 1980
(data source: KOREA TRANSPORT DATABASE, )

# 1.1 Research Background

- Also, many researches about factors on marine accidents have been conducted. But mostly, the researchers focused on human factors. (Lee, 1969, Lim, 1974, Park, 1007, Yang, 2013, Jeong, 2016).

- However, it is essential to take account various factors including natural environmental elements(Lee et al., 2011, Jeong et al., 2013, Marty et al., 2005, Jackson et al., 1985, Uluscu et al., 2009).

- Out of many aspects that cause marine accident, this study is focused on geomorphological factors.

# 1.2 Research Objective

- The aim of the study is;

A. to analyze space-time patterns of the marine accidents
B. to find geomorphological characteristics of the hotspots of the marine accidents

- There are various types of the marine accidents from collision to fire on the ship.
- However, this study is concentrated on ‘ship grounding’ among types of the marine accidents, which the cause is not researched enough in Korea.

# 2. Data and Methodology

**Data**

A. Ship grounding accidents data (by Korea Maritime Safety Tribunal)
B. Marine geographical names data (by KHOA)
C. Bathymetry data (by GEBCO)

**Geospatial Analysis**

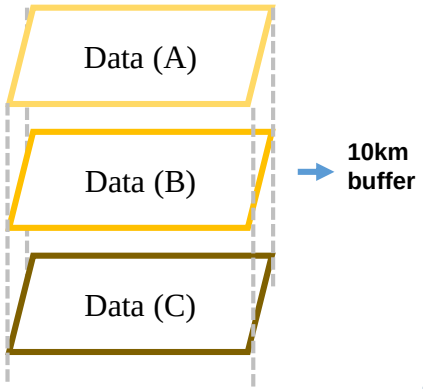
① **Kernel Density Analysis**
(Silverman, 1988)

❖ Data (A) → Hotspots

② **Space-Time Cube Analysis**

❖ Data (A) → Spatial&Time patterns

③ **Overlay Analysis**




④ **Mapping Bathymetry**

❖ Data (C) →

Bathymetry map of the hotspots

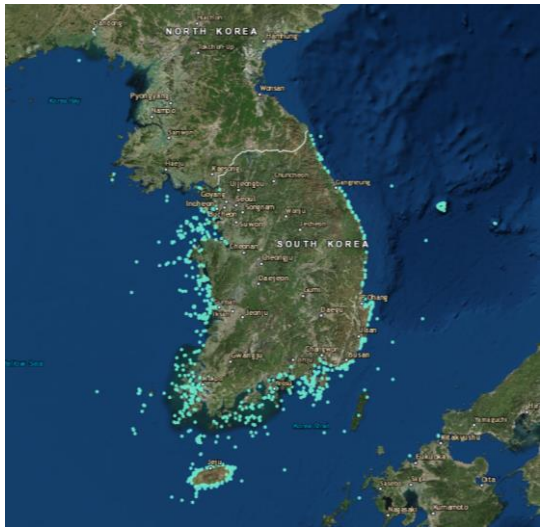
**Interpretation**

Spatial patterns of the marine accidents

Geomorphological characteristics of the hotspots of the ship grounding accidents

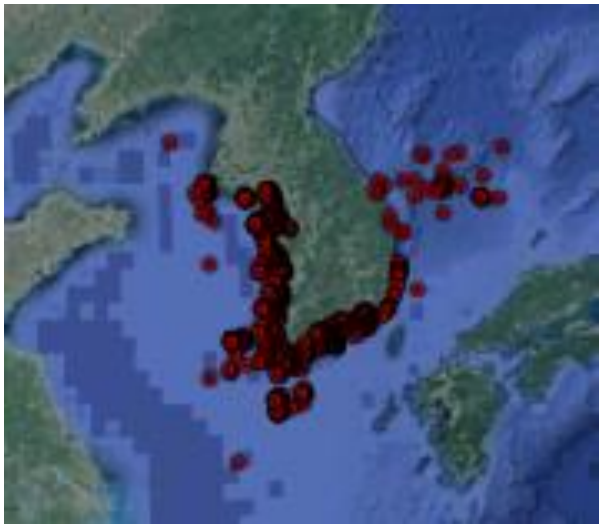
# 2. Data and Methodology

## Data (A)
(KMST)



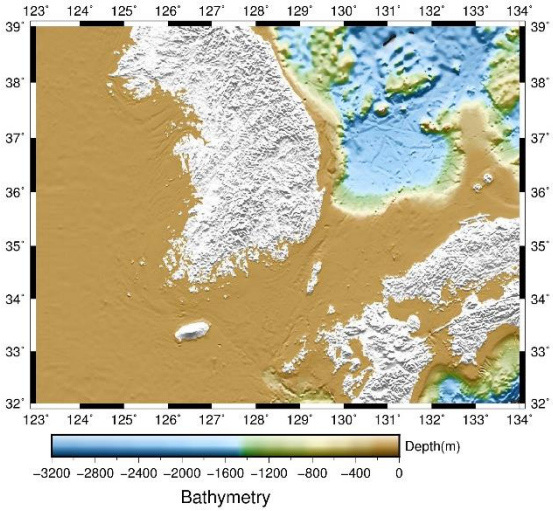

- Location of marine grounding accidents
- Time : 1997-2016
- Around 1,000 Point data

## Data (B)
(KHOA)



- Location of marine geographical names
- Generic Terms: Sea, Gulf, Bay, Strait, Passage, Rock, Reef etc.
- Around 960 point data

## Data (C)
(GEBCO)




- Bathymetry data around Korea

# 2. Data and Methodology

**Data**

A. Ship grounding accidents data (by Korea Maritime Safety Tribunal)
B. Marine geographical names data (by KHOA)
C. Bathymetry data (by GEBCO)

**Geospatial Analysis**

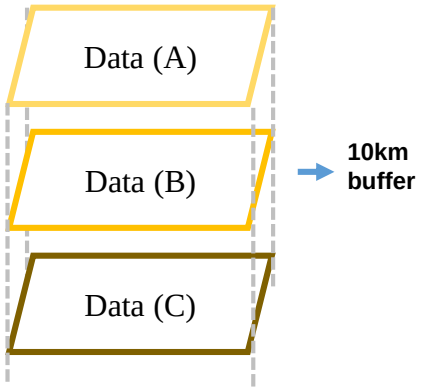
① **Kernel Density Analysis**
(Silverman, 1988)

❖ Data (A) → Hotspots

② **Space-Time Cube Analysis**

❖ Data (A) →
Spatial-Time patterns

③ **Overlay Analysis**




④ **Mapping Bathymetry**

❖ Data (C) →

Bathymetry map of the hotspots

**Interpretation**

Spatial-Time patterns of the marine accidents

Geomorphological characteristics of the hotspots of the ship grounding accidents

# 2. Data and Methodology

- Kernel Density Analysis (ArcGISpro 1.4)

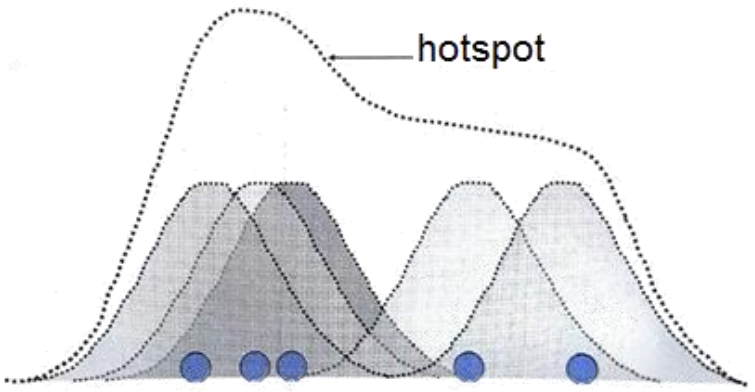
The kernel density analysis is based on the quartic kernel function(Silverman,1986).

$$\hat{f}_h(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

$$K(x) = \frac{3}{4}(1 - x^2), |x| \leq 1$$

$$K(x) = 0, x > 1$$

*h is the bandwidth,*
*x-Xi is the distance to each village with anthrax i.*
*K is the quadratic kernel function.*




Density is estimated using two different distance parameters in the respective kernel functions

# 2. Data and Methodology

- Space Time Cube and Emerging Hot Spot Analysis (ArcGISpro 1.4)
  - The Hot Spot analysis method is calculating the Getis-Ord Gi* statistic.

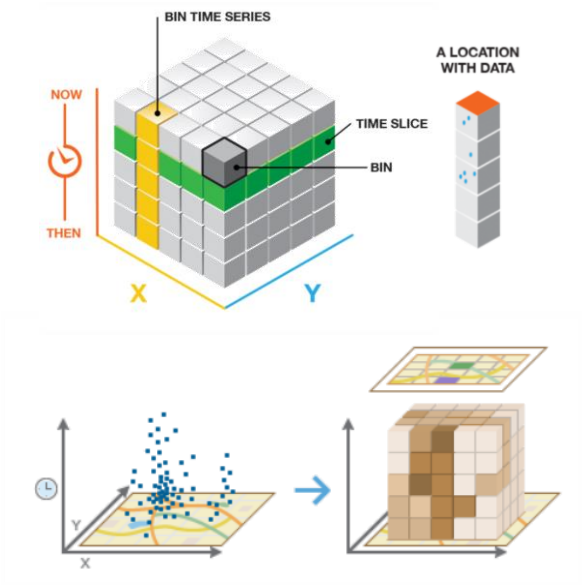



Figure 2 Illustration of space-time cube (pro.arcgis.com)

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}}$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}$$

*$x_j$ is the attribute value for feature j*
*$w_j$ is the spatial weight between feature i and j.*
*n is equal to the total number of features*

# 2. Data and Methodology

**Data**

A. Ship grounding accidents data (by Korea Maritime Safety Tribunal)
B. Marine geographical names data (by KHOA)
C. Bathymetry data (by GEBCO)

**Geospatial Analysis**

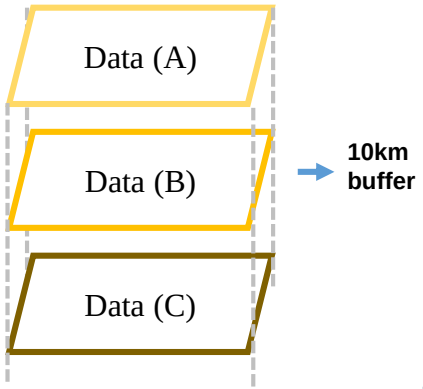
① **Kernel Density Analysis**
(Silverman, 1988)

❖ Data (A) → Hotspots

② **Space-Time Cube Analysis**

❖ Data (A) →
Spatial-Time patterns

③ **Overlay Analysis**




④ **Mapping Bathymetry**

❖ Data (C) →

Bathymetry map of the hotspots

**Interpretation**

Spatial-Time patterns of the marine accidents

Geomorphological characteristics of the hotspots of the ship grounding accidents

# 3. Patterns of Marine Accidents Occurred in Korea

## 3.1 Kernel Density map

- The figure 3 is Kernel Density map of the grounding accidents

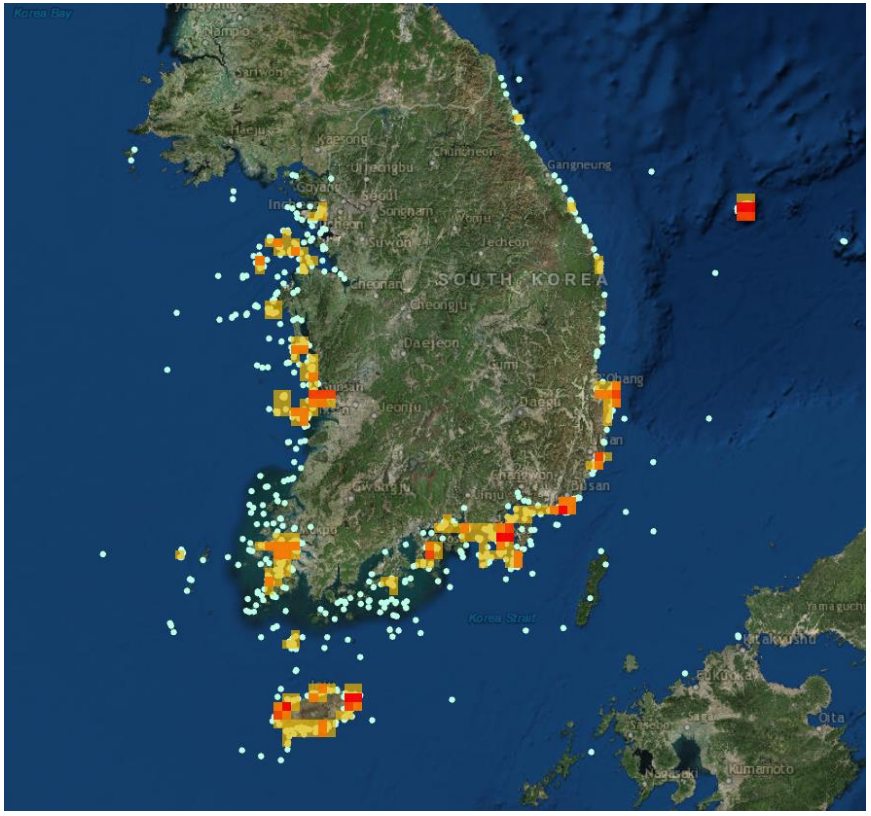



Figure 3 Kernel Density map of the Marine Accidents.
(bandwidth of 15 km with an output cell size of 100km2)

- the Yellow Sea and southern coast of Korea
- The Hotspots were characterized by **major port location** and **port-based industrial distribution of Korea.**

# 3. Patterns of Marine Accidents Occurred in Korea

## 3.1 Kernel Density map

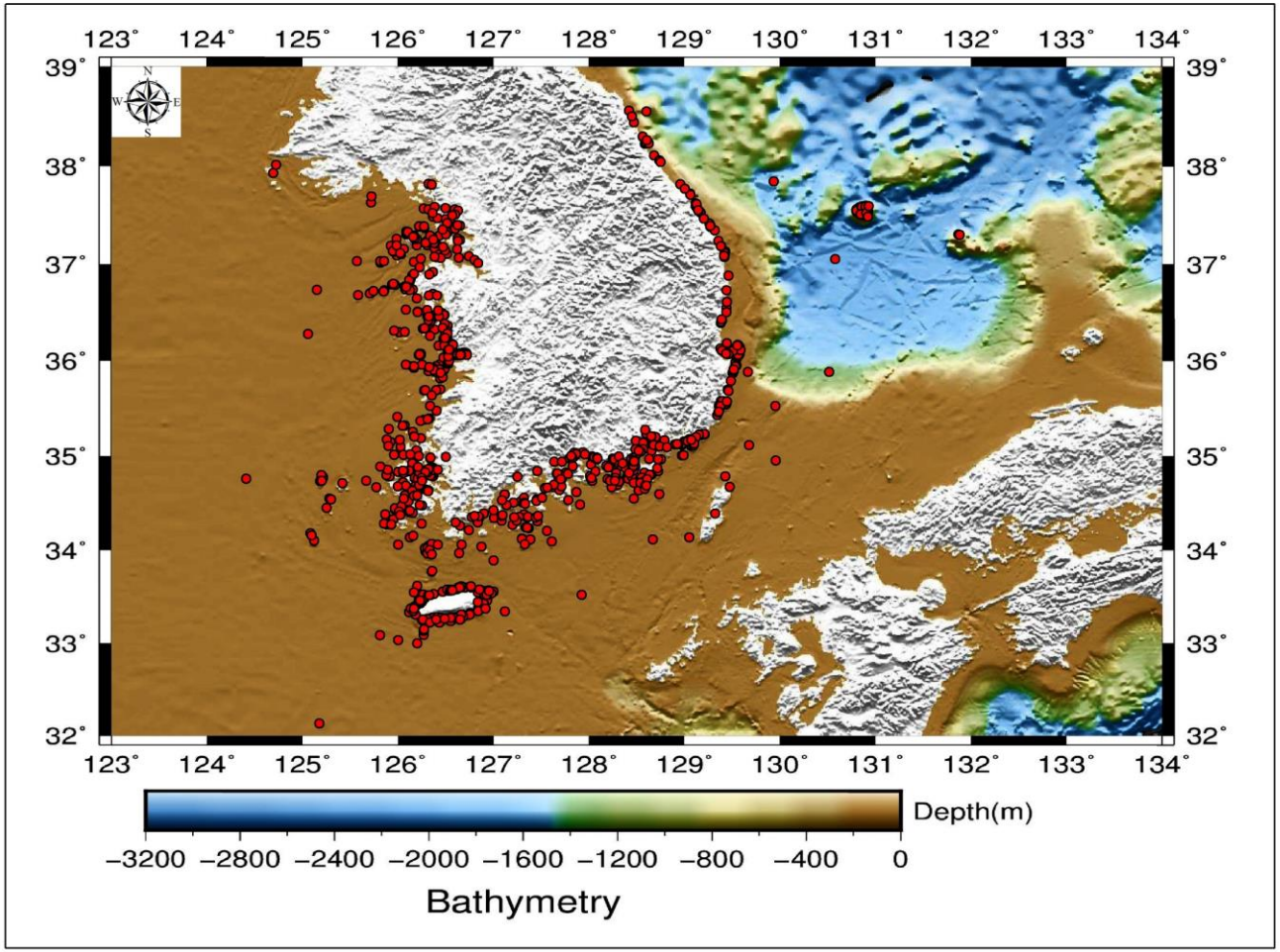



Figure 4 Basic Bathymetry Map of Korea

# 3. Patterns of Marine Accidents Occurred in Korea

## 3.2 Space Time Cube and Emerging Hot Spot Analysis

- Emerging hot spot analysis based on STC was performed
- There are three types, new, sporadic and **consecutive** hot spot.

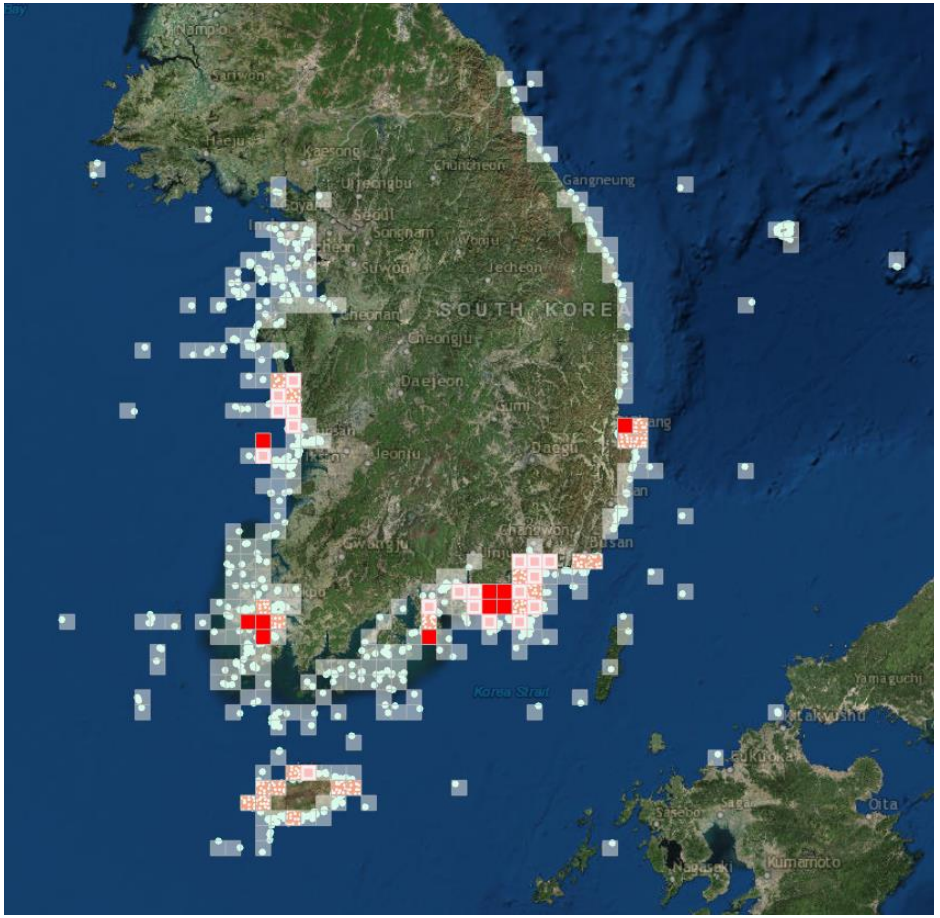



Figure 5 Hotspots analysis map of the grounding accidents based on space time cube by a year.

# 3. Patterns of Marine Accidents Occurred in Korea

## 3.2 Space-time pattern of the marine accidents

- The red cell means '**Consecutive Hot Spot**' where the grounding accidents have been continuously occurred.

***Around the Tongyeong***

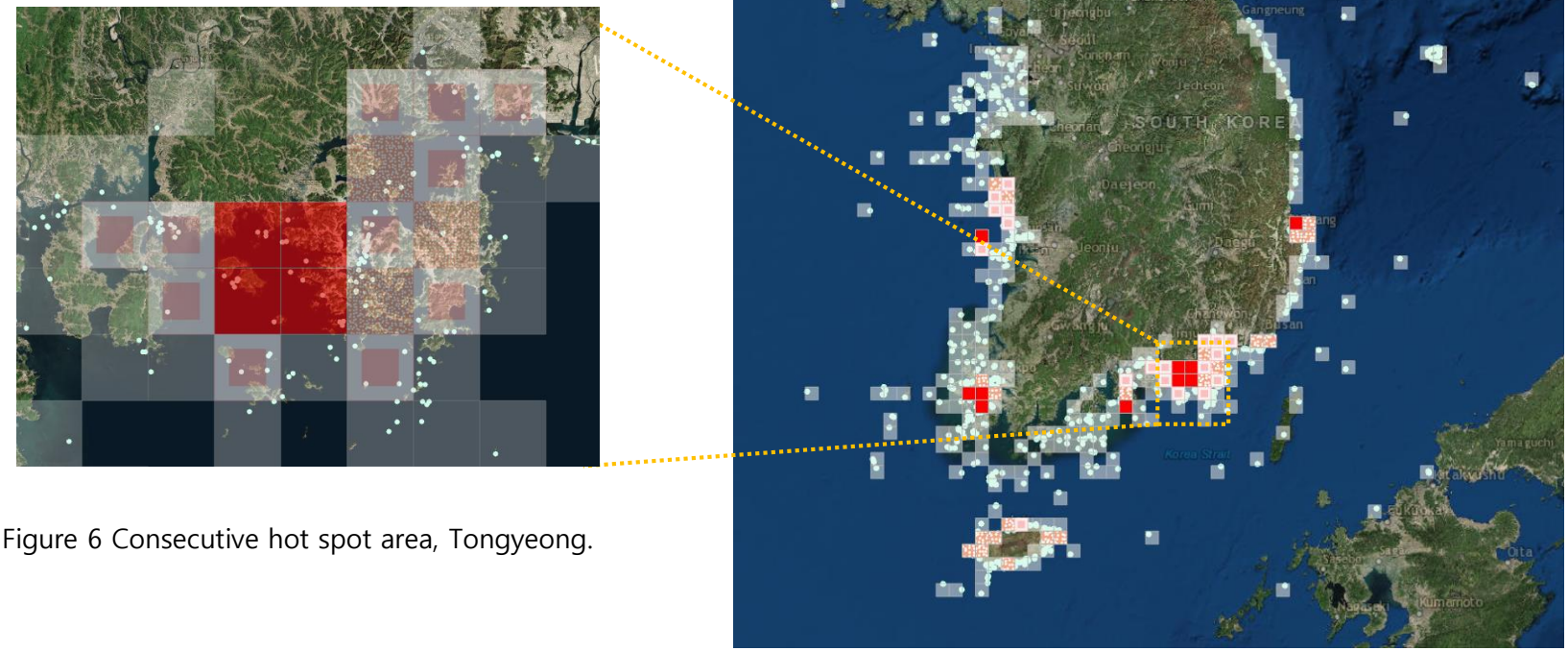



Figure 6 Consecutive hot spot area, Tongyeong.

# 3. Patterns of Marine Accidents Occurred in Korea

## 3.2 Space-time pattern of the marine accidents

- On the other hand, monthly differences of the accidents **did not appear** clearly.

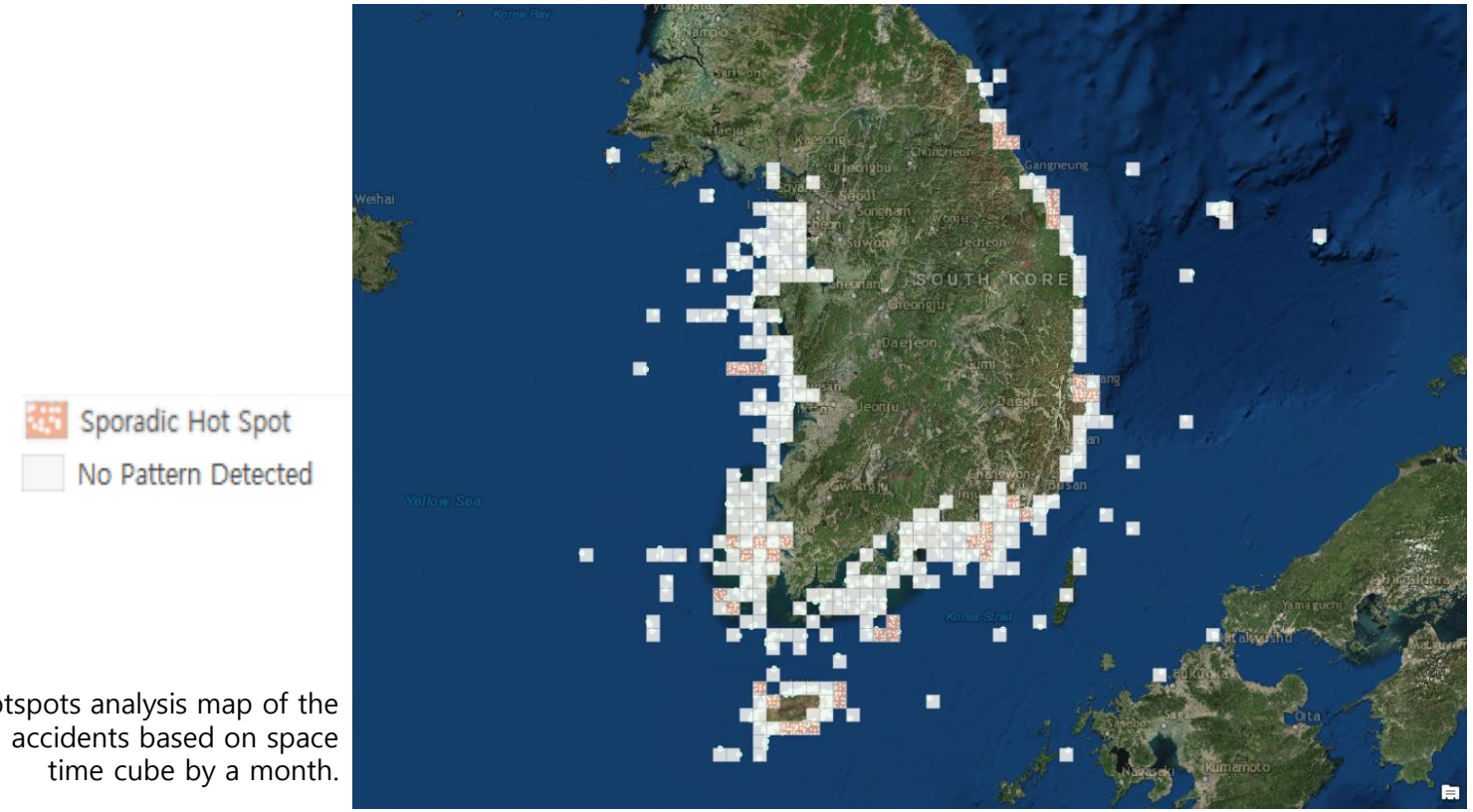
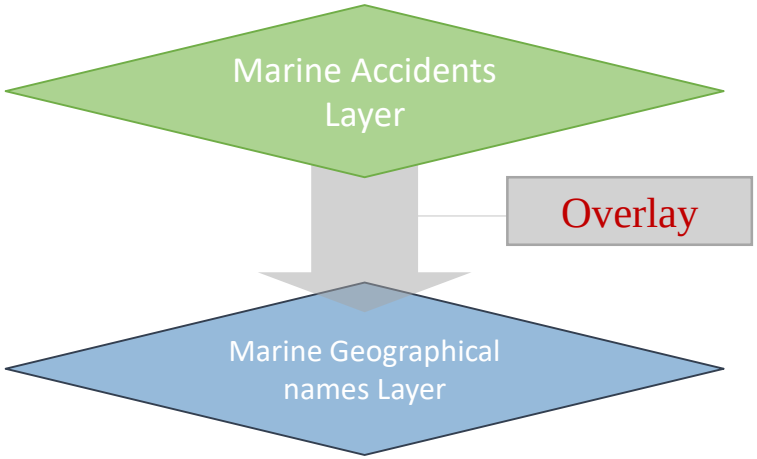



Figure 7 Hotspots analysis map of the grounding accidents based on space time cube by a month.

# 4. Geomorphological Characteristics of the Hotspots of the Marine Accidents

- Overlaying the marine accidents layer with the marine geographical names layer.
  - The geographical names consist of the specific and the generic term.
  - We could infer a geomorphological characteristics through **the generic term**.

- 10km buffer polygons of the grounding point were created.



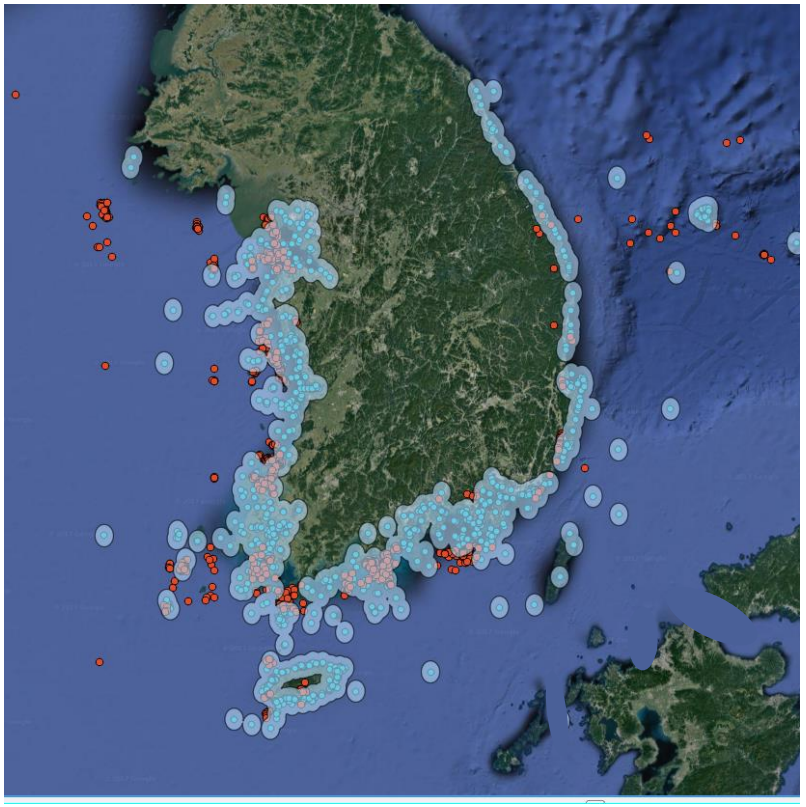



Figure 8 Overlaid the marine accidents layer and the feature names layer.

# 4. Geomorphological Characteristics of the Hotspots of the Marine Accidents

- After, the percentage of which generic terms in the buffer zones around the Tongyeong was calculated.

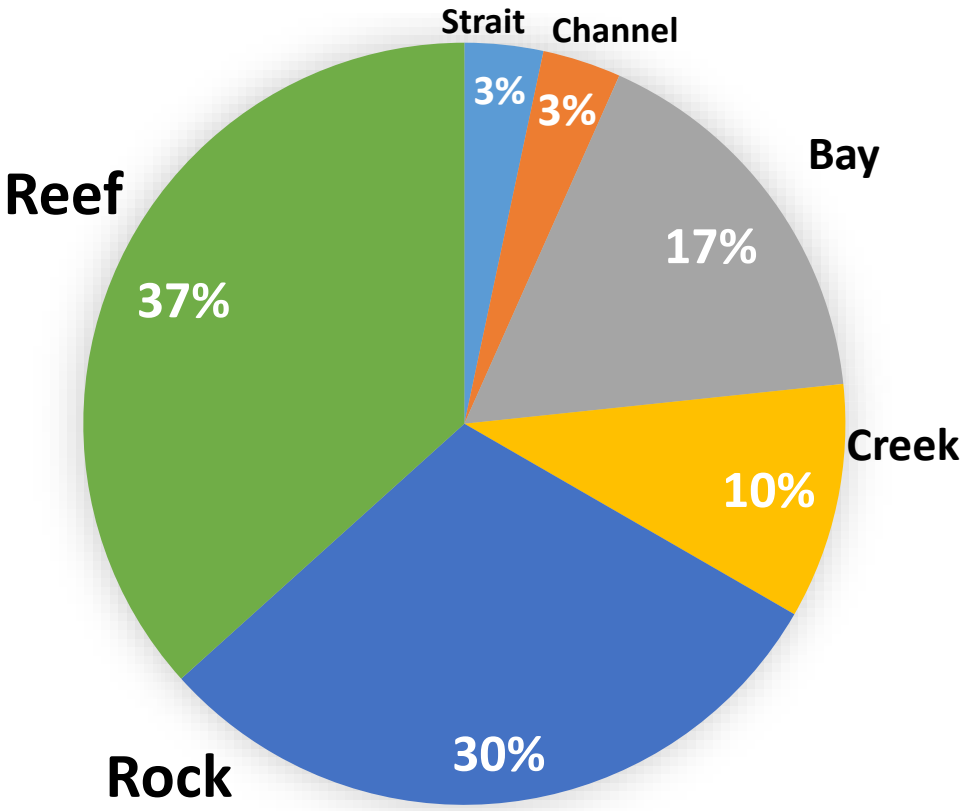
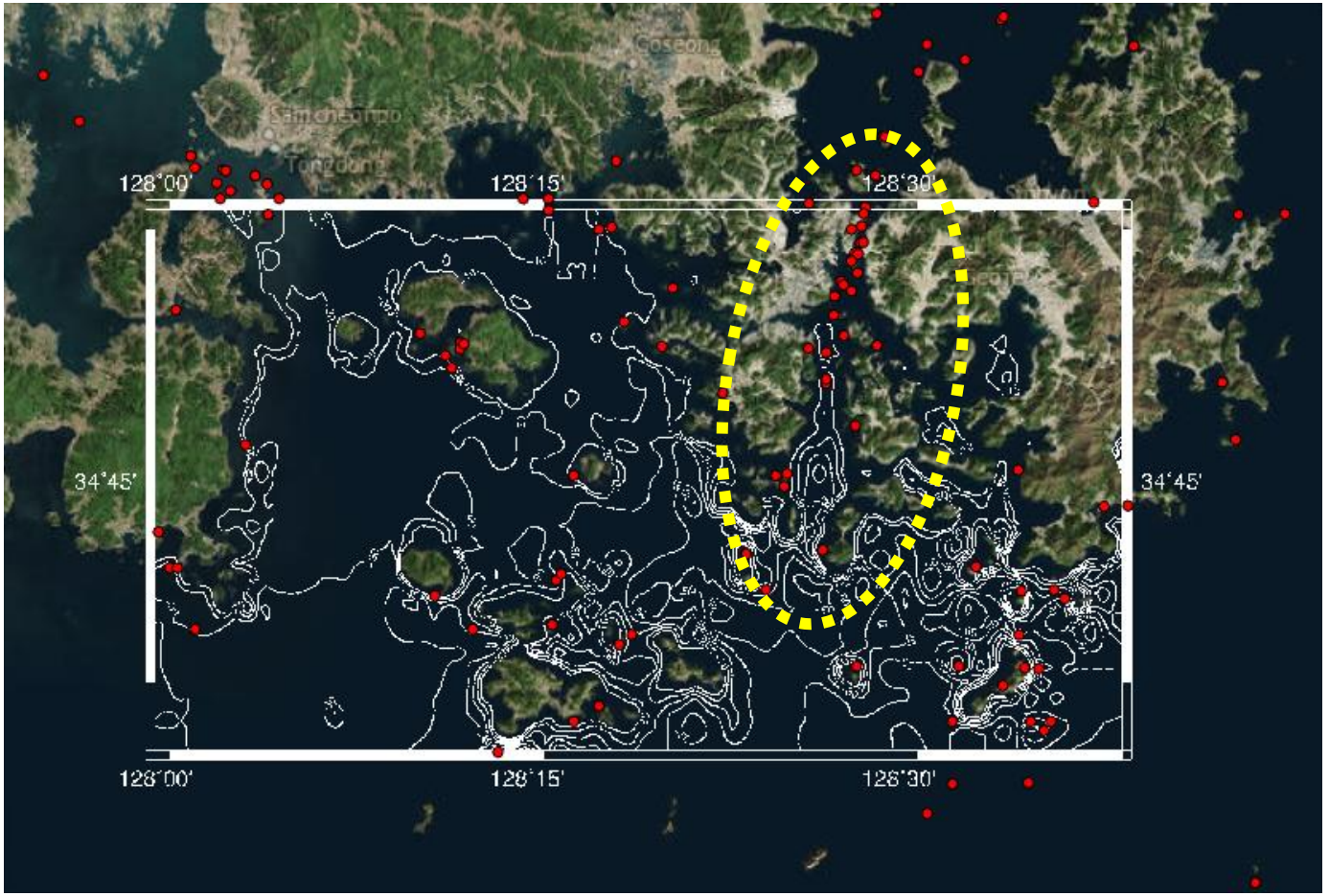



Figure 9 the percentage of the generic terms in the buffer zones.

# 4. Geomorphological Characteristics of the Hotspots of the Marine Accidents

- The bathymetry map of around Tondyeong was constructed(GMT 5.1.0).



# 5. Conclusion

- The area near the Yellow sea and the southern coast of Korea shows high kernel density.
- The area around the Tongyeong is the ‘consecutive hot spot’ as a result of Space Time Cube analysis.
- As geomorphological characteristics, the ‘Reef’ and ‘Rock’ are mainly found in the hotspot areas among generic terms of undersea feature names.
- In addition, many ship groundings have occurred in the channel, especially in area with narrow width and shallow depth.

# *Reference*


A. H. Bouma, 1990, Naming of undersea features, Geo-Marine Letters 10(3), 119-125

Balmat, J. F., Lafont, F., Maifret, R., & Pessel, N., 2011), A decision-making system to maritime risk assessment. Ocean Engineering, 38(1), 171-176.

Botev, Z. I., Grotowski, J. F., & Kroese, D. P., 2010, Kernel density estimation via diffusion. The Annals of Statistics, 38(5), 2916-2957.

C. C. Baker, D. B. McCafferty, 2005, Accident database review of human element concerns: What do the results mean for classification?, Human factors in ship design, safety and operation, February 23-24, 2005, Royal Institution of Naval Architects, London

Cho, D. O. (2005). Challenges to marine debris management in Korea. Coastal Management, 33(4), 389-409.

Dobbins, J. P., & Abkowitz, M., 2010, Use of advanced information technologies for marine accident data analysis visualization and quality control. Journal of Transportation Safety & Security, 2(1), 1-13.

Du Bois, P. B., Garreau, P., Laguionie, P., & Korsakissok, I., 2014, Comparison between modelling and measurement of marine dispersion, environmental half-time and 137Cs inventories after the Fukushima Daiichi accident. Ocean Dynamics, 64(3), 361-383.

Hamed, K. H., 2009, Exact distribution of the Mann-Kendall trend test statistic for persistent data in Journal of Hydrology, 86–94.

Husrin, S., Kelvin, J., Putra, A., Prihantono, J., Cara, Y., & Hani, A., 2015, Assessment on the Characteristics and the Damping Performance of Coastal Forests in Pangandaran after the 2006 Java Tsunami, Procedia Earth and Planetary Science 12, 20-30.

J. Marty, S. Potter, 2010, Risk Assessment for Marine Spills in Canadian Waters, Phase 1: Oil Spills South of the 60th Parallel, the Commissioner of the Environment and Sustainable Development

Keith A. Sverdrup, E. V. Armbrust, 2008,『An Introduction to the World'S Ocean』, Mc Graw Hill

Kendall, M. G., Gibbons, J. D., 1990, Rank correlation methods, fifth ed., Griffin, London.

Kraak, M. J., 2003, The space-time cube revisited from a geovisualization perspective. In Proc. 21st International Cartographic Conference.

K. Ioanna, N. Zoe, G. Theodoros, P. Stavros, C. Eleni and G. Sotirios., 2015, A dynamic model for environmentally safe shipping through the Aegean Sea, Information, Intelligence, Systems and Applications (IISA), 2015 6th International Conference on Marty.

# *Reference*


L. F. Jackson, S. R. Lipschitz, 1985, Sensitivity Mapping: An Aid To Contingency Planning On Southern African Shores, Sea Fisheries Research Institute Private Bag X2, Roggebaai 8012, Republic of South Africa

Mann, H. B., 1945, Nonparametric tests against trend in Econometrica, Vol. 13, 245–259

Soares, C. G., & Teixeira, A. P. (2001). Risk assessment in maritime transportation. Reliability Engineering & System Safety, 74(3), 299-309.

Shimazaki H. and Shinomoto S., 2007, A method for selecting the bin size of a time histogram in Neural Computation, Vol. 19(6), 1503–1527.

Ulusçu, Ö. S., Özbaş, B., Altıok, T., & Or, İ. 2009, Risk analysis of the vessel traffic in the strait of Istanbul. Risk Analysis, 29(10), 1454-1472.

T. Garrison, R. Ellis, 2014, 『Oceanography』, Sengage Learning

Terrell, G. and Scott, D., 1985, Oversmoothed Nonparametric Density Estimates. Journal of the American Statistical Association, Vol. 80(389), 209-214.

WSP, 2014, Risk Assessment for Marine Spills in Canadian Waters: Phase 1, Oil Spills South of the 60th Parallel, Report from WSP Canada Inc. to Transport Canada, 172 p. and appendices

Worton, B. J., 1989, Kernel methods for estimating the utilization distribution in home-range studies. Ecology, 70(1), 164-168.

B.W. Silverman, 1986, Density estimation for statistics and data analysis, New York: Chapman and Hall

Fotheringham, S., & Rogerson, P. (Eds.). 2013, Spatial analysis and GIS. CRC Press.

General Bathymetric Chart of the Oceans (gebco.net)

KOREA HYDROGRAPHIC AND OCEANOGRAPHIC AGENCY (khoa.go.kr)

Korea Transport Database (ktdb.go.kr)

Korea Maritime Safety Tribunal (kmst.go.kr)

# Q & A

Thank you
for your attention