FIELD INVESTIGATIONS FOR TOPOGRAPHICALLY CONTROLLED RIP CURRENTS AT ENSHU NADA COAST

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1. Introduction

Among all the other factors causing drowning deaths in Japan and in other countries, rip currents are known as the most deadly threats for beachgoers and surfers. According to the statistics in Japan Lifesaving Association (JLA) annual patrol log, it is stated that 40.3% of the rescues in 2010 around Japan are caused by rip currents (JLA, 2010).

There are several types of rip currents caused by various aspects such as structurally controlled rips, flash rips and mega rips. In this research, we focused mainly on topographically controlled rips, which are the common and dangerous form of rip currents caused by morphology of seabed. These rips can persist in the same location for weeks, months or even years but storms may change the dimensions and locations of sandbars which then alter formation of the rip currents.

The objective of this research is to reduce rip currents related accidents, especially topographically controlled rips by carry out various types of field investigations to study about the mechanism of these rips.

2. Topographically Controlled Rips Investigation at Enshu Nada Coast

Formations of topographically controlled rips are directly related to the morphology of seabed. Therefore, the purpose of this investigation is to study the mechanism of topographically controlled rips. Field investigations involving rips identification from shore and rips registrations using Handy GPS were carried out twice along Enshu Nada Coast to check the formations of these rips. The investigations were carried out on 28th October 2015 and on 22nd November 2015, both on sunny days with average wind speed of 5.0 m/s and 1.7 m/s respectively. Geographical positions of rip currents were then correlate with bathymetry data of Enshu Nada Coast which is mentioned in Chapter 4. **Fig. 1** is a picture of identified rip currents.

The registered rips are divided into Region A, which is located on the west side of Imagire-guchi Inlet and Region B that is located on the east side of the inlet. Three rips that were registered in Region A and the other one rip in Region B in **Fig. 2** are marked with red arrows to indicate them as topographically controlled rips due to the presence of channel-like features. The other two rips that are marked with blue arrows were identified occurring in same locations in both field investigations and can be categorized as topographically controlled rips while the rest might be weak flash rips.

3. Topography Monitoring Analyzation of Enshu Nada Coast

Bathymetry data is obtained through fish finder data installed on 24 existing shirasu fishing boats that operate almost every day along the coast of Enshu Nada (Okabe et al., 2013). The data is divided into Region 1 on the east side of Imagire-guchi Inlet with a range of 4.5 km and Region 2 on the west side of the inlet with a range of 8 km. Both regions are analyzed through two states, annual bathymetry from 2008 to 2015 to show the transformation of the sandbars and rip channels over the years and short term periods before and after typhoons in October 2014 to determine the migration of rip channels under the influence of typhoons.

From the annual bathymetric analyzations, the number of channels and averaged rips spacing of Region 1 and 2 are shown in **Table 1.** Significant changes such as development of multiple channels started in 2011 in both regions

As for short term changes of bathymetry under the influence of typhoons in **Fig. 3**, the difference in depth between P1 (2014/8/12~2014/10/3) and P2 (2014/10/15~ 2014/11/28) is shown in **Fig. 4**. Erosion of rip channels up to 2.4 m is shown with arrows to show the development of channels. Rip channels is further presented through cross section of L1 in **Fig. 5**. Channels in L1 migrated with an average of 71 m westwards under the influence of typhoons.

Rips spacing Y_r is defined by

$$Y_r = 1.08T^{1.41}{H_b}^{0.54}(\tan\beta)^{-0.64} \qquad (1)$$

where T represents wave period, H_b is breaking wave height and $\tan\beta$ is the gradient of the seabed (Horikawa et al., 1973).

Fig. 1 Photo of rip current at Enshu Nada Coast

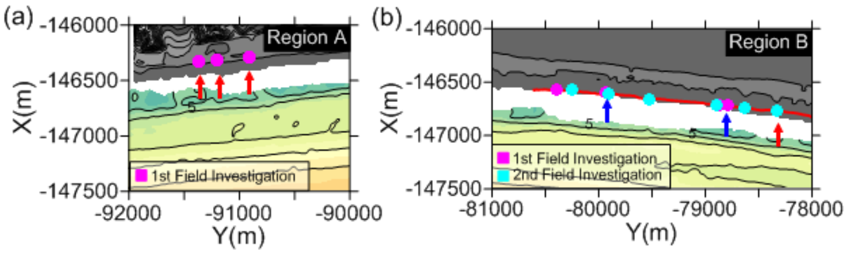

Fig. 2 Registered rip currents in (a) Region A, (b) Region B

Table 1 Annual changes in number of channels and rips spacing

Year	Region 1		Region 2	
	Number of channels	Rips spacing (m)	Number of channels	Rips spacing (m)
2008	1	0	0	0
2009	3	782	5	746
2010	2	358	1	0
2011	8	515	11	493
2012	7	527	10	746
2013	9	438	8	955
2014	11	303	6	419
2015	3	328	5	737

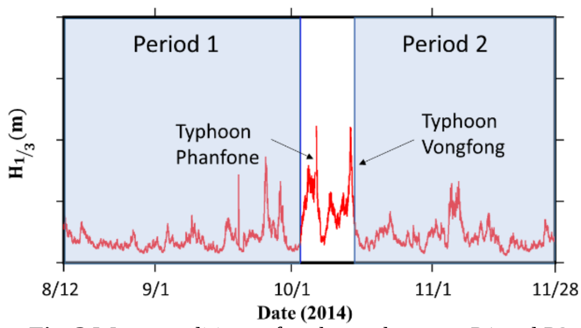

Fig. 3 Wave conditions of typhoons between P1 and P2

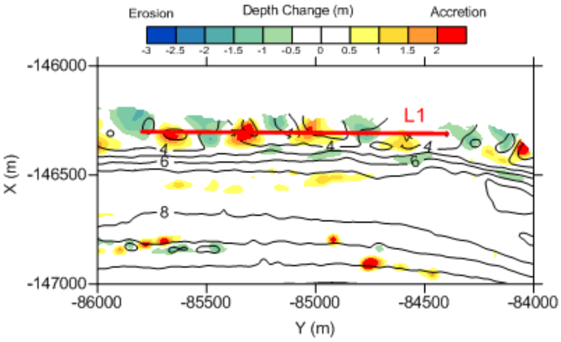

Fig. 4 Depth change before and after typhoon in Region 2

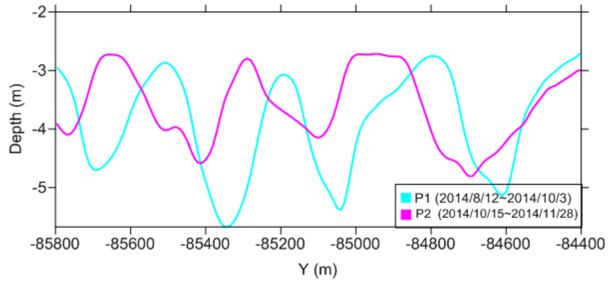

Fig. 5 Sections of longshore L1 before and after typhoons

During typhoon period where average significant wave height $\overline{H_{1/3}}$=1.66 m and average wave period $\overline{T_{1/3}}$ =8.85 s, rips spacing Y_r=596 m. While during P1 and P2, $\overline{H_{1/3}}$=0.78 m and $\overline{T_{1/3}}$ =6.52 s, Y_r=271 m. Rips spacing during typhoon period appeared to be larger, while during P1 and P2, calculated rips spacing is almost the same as the one observed during field investigations. This shows that rips spacing of topographically controlled rips tend to be narrower during non-typhoon period and may cause higher risk to unwary beachgoers.

Fig. 6 Beach shops at Fudodo Beach

4. Beach Management Problems in Japan

Another field investigation was carried out at Fudodo Beach, Chiba to identify the flaws in Japan's beach safety management against rip currents. From the field investigation, fixed rips were seen occurring at the swimming area in front of the beach shops. Both beach shops at Fudodo Beach are permanent type as shown in **Fig. 6**, which are impossible to be moved flexibly. This means that the swimming area is also established in front of the beach shops and cannot be moved flexibly due to local regulations and also approval of beach shop owners (Ishikawa et al., 2014). Rips related drowning accidents can only be prevented with the help of lifesavers. However, during peak seasons such as summer holidays, the ratio of lifeguards to beachgoers is approximately 1:2700 which is significantly insufficient.

This is extremely dangerous to beachgoers. Therefore, a more thorough countermeasure against fixed rips such as topographically controlled rips is essential to ensure the safety of beachgoers.

5. Conclusion

Field investigations including rips identification from shore and rips registration have been carried out to study the mechanism of topographically controlled rips. Bathymetry of Enshu Nada that is studied in long-term period from 2008 to 2015, and in shorter period of time, before and after typhoon showed that topographically controlled rips occurred near rip channels and can persist in the same location for a period of time. While results from rips spacing showed that these rips tend to occur more during non-typhoon period. Field investigation at Fudodo Beach proved that beach management in Japan is inflexible and is unable to provide a safe environment to beachgoers. Hence, based on the understanding of topographically controlled rips, a more thorough beach management is needed.

Reference

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