**PROJECT TITLE:** **Dangerous Current Prediction on Lake Superior Minnesota Coast**

**I. PROJECT STATEMENT**

The goal of this proposal is to create a forecast and alert system for dangerous currents on the Minnesota coast of Lake Superior to provide warmings to the public. Dangerous currents can be life threating to beach-goers and kayakers. In this project, we will: (1) generate an extensive and scientific database characterizing dangerous currents, (2) develop a fast prediction model for dangerous currents, and (3) develop a smartphone app to alert users of dangerous currents and inform local communities. Our study will focus on rip currents.

1. *What are rip currents?*

Rip currents are strong and narrow currents of water flowing away from shore. They can be induced by wind and breaking waves on the water surface. Local geographical characteristics, such as the variation of the coastal bathymetry, sediment morphology, and man-made constructions, can all lead to rip currents. The size of rip currents can be large, reaching 100 feet in width and extending up to 1,000 feet from the shore.

1. *Why are rip currents dangerous?*

The speed of the rip currents is about 0.5 to 1 m/s. Some currents may reach up to 2.5 m/s (MacMahan et al., 2011), which is faster than the swimming speed of most of people or even athletic swimmers, making rip currents dangerous for beach-goers and kayakers. National Weather Service (NWS) reported that 80% of rescues were caused by rip currents. Based on the database of National Oceanic and Atmospheric Administration (NOAA), on average 57 people died from rip currents each year, and 70 died in 2017. Despite the danger, there are a large number of Minnesota beach goers unfamiliar with the danger of rip currents. According to a survey conducted by Jesse Schomberg at MN Sea Grant, 34% of beach users have never heard about rip currents (<http://www.seagrant.umn.edu/downloads/schomberg_ripCurrents-09.pdf>).

1. *What are the impacts of rip currents on society?*

Rip currents are not only life threatening but also highly relevant to socioeconomic health and water-related tourism. Tourism in coastal communities in Minnesota, such as the Duluth area, Two Harbors, Lutsen, Tofte, and Grand Marais, has grown steadily in the last two decades and contributes about $400 million to the economy per year (<http://www.seagrant.umn.edu/recreation/overview>). For example, the Park Point Beach attracts 3.5 million visitors every year (<https://duluthchamber.com/visitors/>). However, the reported drowning incidents induced by the rip currents have negative impacts on the reputation of the beach and harm the local economy. Moreover, the sediments carried by the wave and currents accumulate at the mouth of the harbor, posing dangers to boats and increasing the cost of dredging.

1. *How can we solve this problem?*

There are two major issues preventing the coastal communities on the Minnesota side of shore of Lake Superior from responding to dangerous currents promptly and precisely. First, we do not have enough knowledge about the local dangerous currents, which are transisient and site-specific. Second, no forecasting for the dangerous currents can cover the various coast sites in Minnesota. These two issues are pressing concerns for both tourists and lifeguards. In this project, we will generate an extensive database for rip currents, based on which to train an artificial intelligence (AI) model, and develop a fast and accurate prediction alert system.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1 Title:** Generate database characterizing rip currents on Lake Superior Minnesota coast

**Description:** We will collect data from the field. Remote sensing and field measurement techniques will be used to measure the wind, wave, currents information, such as the wind direction, wave surface elevation and current speed. We have also developed a software called WOW (Wave-Ocean-Wind), which is a powerful model for water and wind motions. In this project, we will use WOW to model the generation of rip currents on the various Lake Superior coast sites in Minnesota under different conditions, including waves with different amplitudes and wavelengths, various bathymetries, and different sediment transport. We will compare our model data with measured data to validate and improve our methodology. The validated data will be used to establish a database characterizing rip currents on Lake Superior’s Minnesota coast.

**ENRTF BUDGET: $149,991**

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| **Outcome** | **Completion Date** |
| 1. Measurement data of rips currents  | September 2021 |
| 2. Model data validated by measurements  | June 2022 |
| 3. A comprehensive database on rips currents on Lake Superior’s Minnesota coast | September 2022 |

**Activity 2:** Develop a fast prediction model to forecast dangerous currents on Lake Superior Minnesota Coast

**Description:** We will use the database generated in **Activity #1** to train a fast prediction model based on the neural network, which is a mature and broadly used technique of artificial intelligence (AI). The developed model will be efficient enough to predict the dangerous current events in advance, with the wind and wave information given by weather forecast as an input. We will test the model using historical data and field measurement data to be obtained in this project.

**ENRTF BUDGET: $89,994**

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| **Outcome** | **Completion Date** |
| 1. An AI model trained using the database produced in **Activity #1**  | December 2022 |
| 2. Validation of the model using measurement data | March 2023 |

**Activity 3:** Develop a smartphone app to alert dangerous currents and help local communities

**Description:** We will integrate the fast prediction model produced in **Activity #2** and a user-friendly interface to develop a smartphone app to forecast dangerous currents in Lake Superior. Our app will collect data of wind conditions and wave states 24/7 automatically and deliver the dangerous current report to users in a timely manner. This app will foster the social, economic, and environmental sustainability of the regions on Lake Superior in Minnesota by promoting the waterfront safety.

**ENRTF BUDGET: $59,997**

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| **Outcome** | **Completion Date** |
| 1. Develop an app to alert dangerous currents on Lake Superior Minnesota coast  | June 2023 |

**III. PROJECT PARTNERS AND COLLABORATORS:**

This project will leverage on two other projects of Prof. Lian Shen. The first is a project sponsored by Office of Naval Research on the study of coastal environment (collaborators include Pablo Carrica and Casey Harward at University of Iowa and Kenneth Weems at Naval Surface Warfare Center). The second is a joint Minnesota and Wisconsin Sea Grant project on the South Shore of Lake superior (collaborators include Chin Wu at University of Wisconsin and Jerald Henneck at Natural Resources Research Institute). While these projects can share research tools and data, it should be pointed out that only through the project proposed here can a forecast and alert system be developed for the entire Minnesota coast of Lake Superior.

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:**

This project will be completed in three years. The long-term strategy is to ensure that the database and design model will be provided to state agencies. The smartphone app will also be provided to the public.

**V. SEE ADDITIONAL PROPOSAL COMPONENTS:**

**A. Proposal Budget Spreadsheet**

**B. Visual Component or Map**

**F. Project Manager Qualifications and Organization Description**