

TSUNAMI PREPAREDNESS WORKSHOP FOR THE MARITIME COMMUNITY

June 27, 2017

Centro de Convenciones de Puerto Rico
San Juan, PR

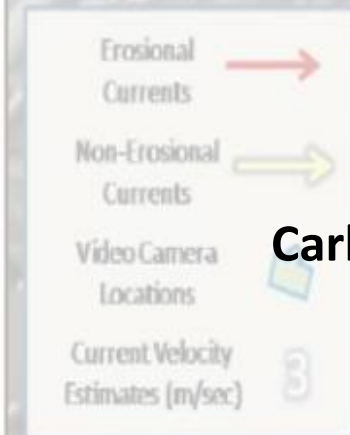
Tsunami Currents Modeling in Ports, Harbors, and Marinas

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Products

Maritime tsunami hazard preparedness products may include maps and plans that are printed, digital files, or interactive/web-based. Based on this information, specific tsunami hazard mapping products are likely most useful to maritime communities:

- 1) **Areas of past tsunami damage and strong currents**
- 2) **Current velocities and relationship to damage**
- 3) **Peak-to-trough water-level fluctuations**
- 4) **Bores, seiches, or amplified waves**
- 5) **Length of time/duration damaging currents are active**
- 6) **Safe minimum offshore depth for vessels**

The Guidelines provide four current speed ranges which should be used for damage assessment:

1. Blue: 0 to 2.9 knots – no observed damage
2. Green: 3 to 5.9 knots – minor to moderate damage
3. Orange: 6 to 8.9 knots – damage observable, transition to major damage
4. Red: larger than, or equal to, 9 knots – major to complete damage

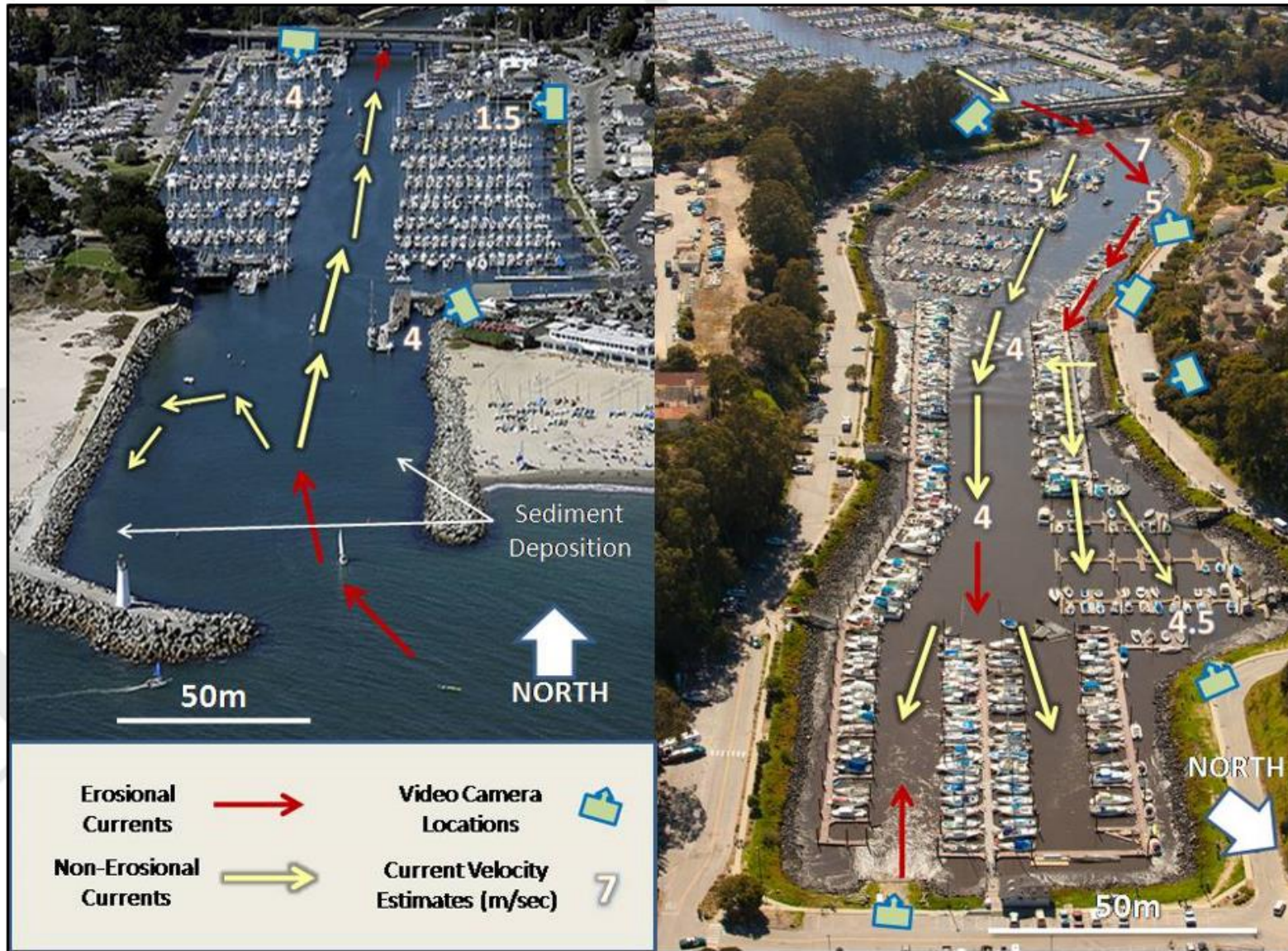


Figure 1 Location of strong and erosional currents inside Santa Cruz Harbor during the 2011 Japan tsunami (from Wilson and others, 2012a).

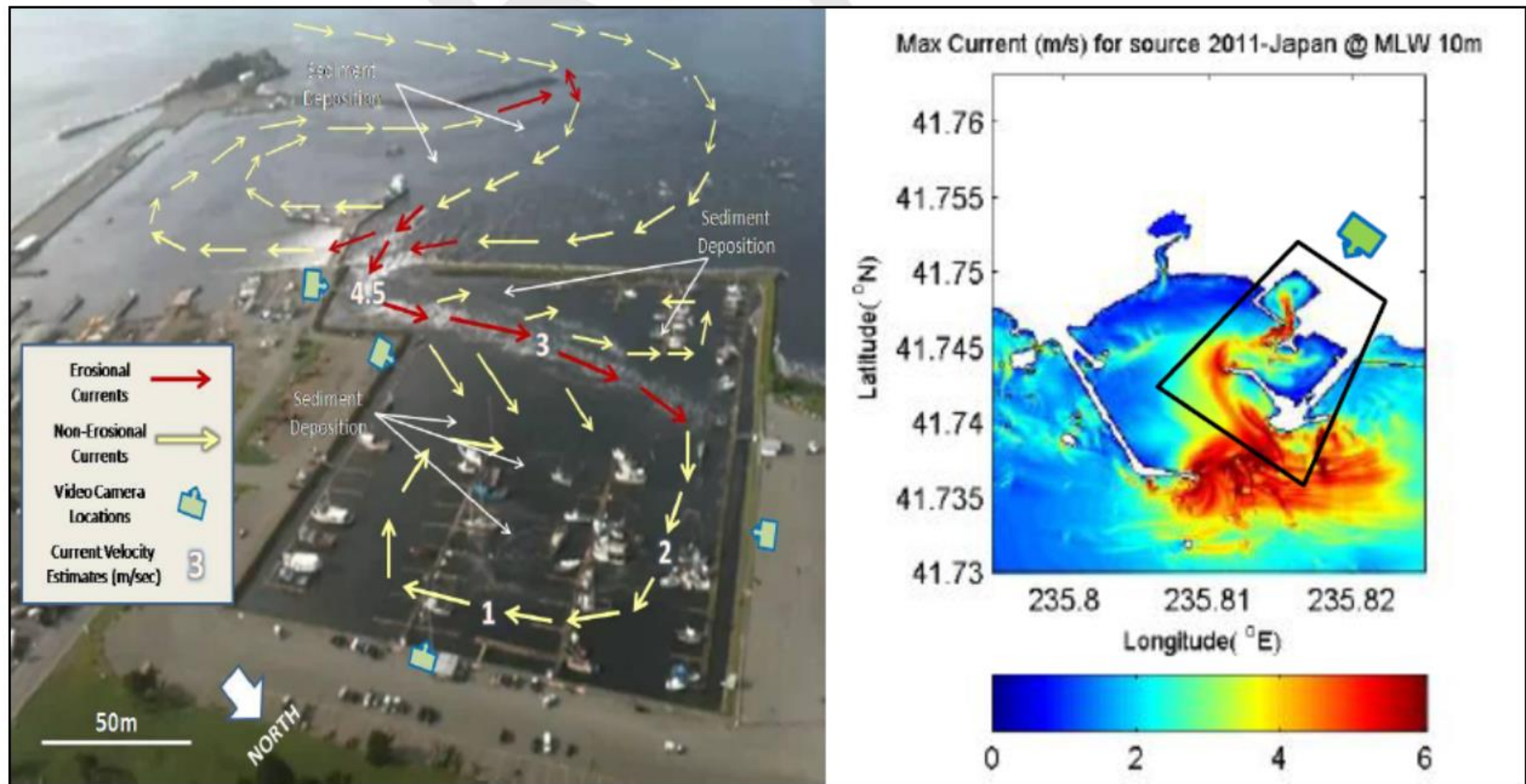


Figure 1 Tsunami flow-regime map for Crescent City Harbor (left) and modeled peak currents using MOST (right) for the March 11, 2011 tsunami. Modeled currents match observed flow patterns and peak velocities.

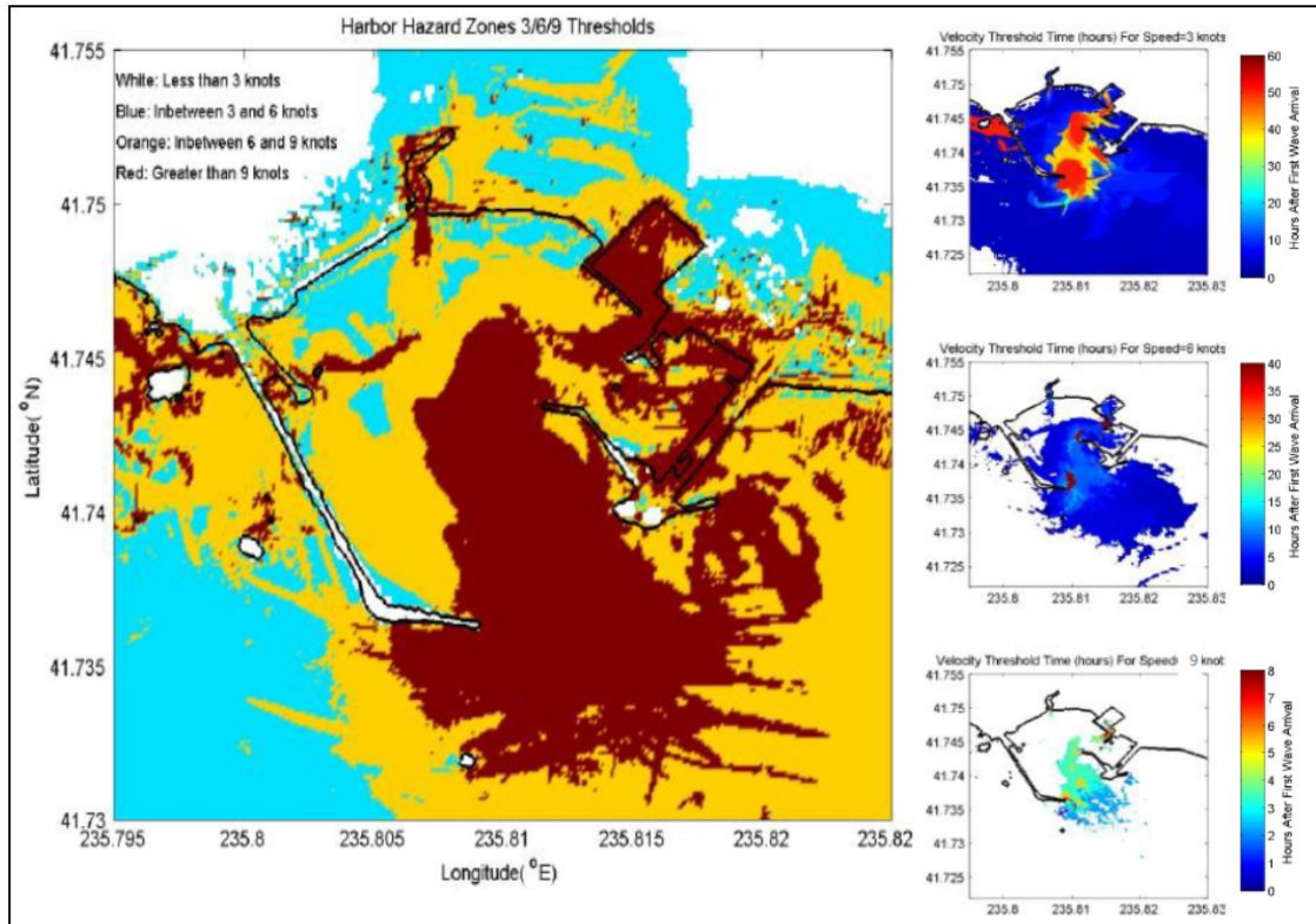


Figure 3 Modeled current velocities for all local and distant sources subdivided by 3-6-9 knot velocity bins related to damage potential (left) and time thresholds tsunami activity for each velocity bin (right). This type of information can be developed for each modeled scenario and used for in-harbor guidance for tsunami response and mitigation planning.

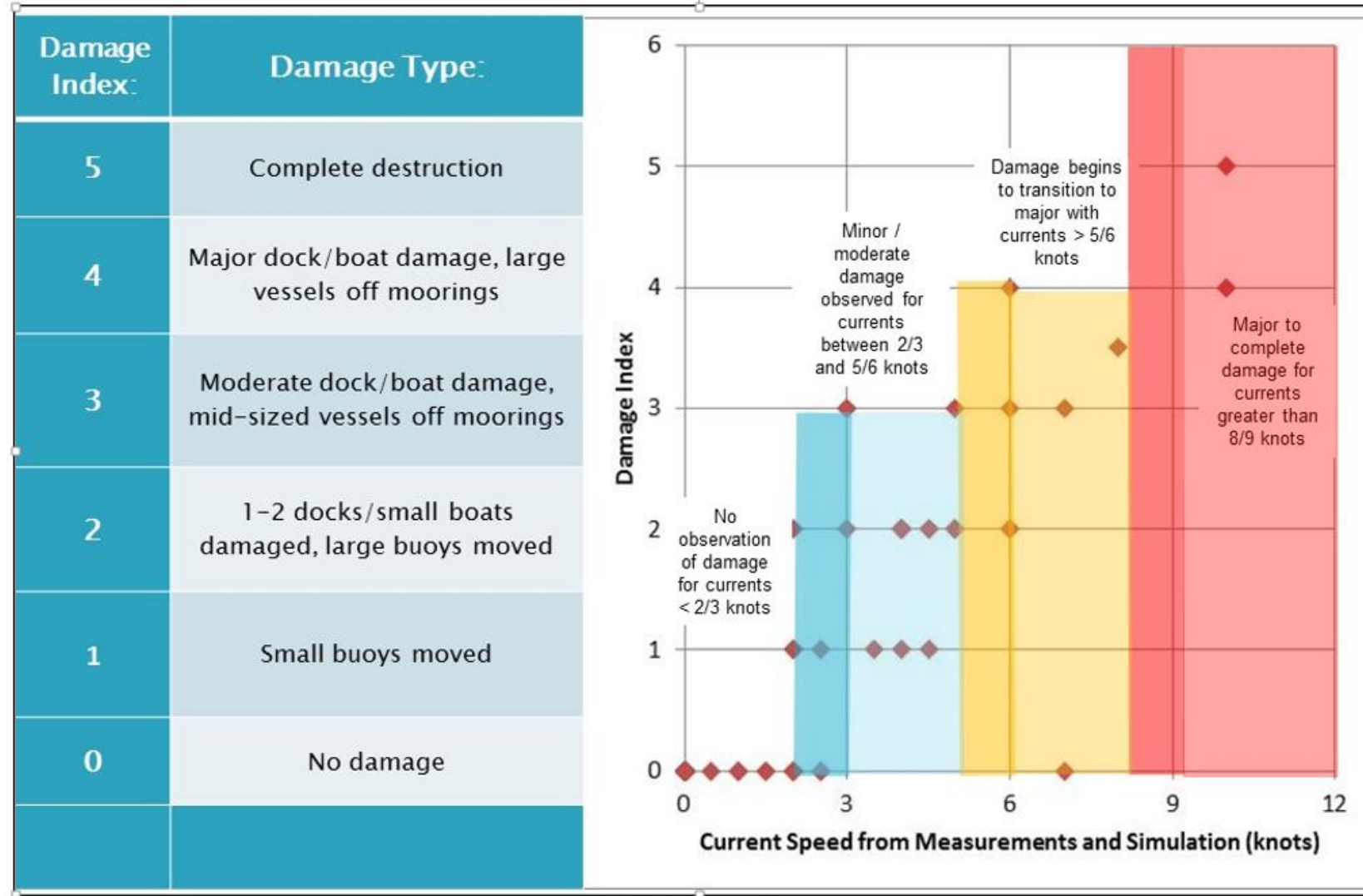


Figure 2 Graphic showing the relationship between strong tsunami currents and damage in a number of harbors and real events. The red points represent damage-current data from past events and tsunami modeling (modified from Lynett and others, 2013).

**REPORT ON THE MINIMUM WATER DEPTH, AND
DISTANCE FROM THE SHORELINE, REQUIRED FOR
MOVING SHIPS AND BOATS OUTSIDE OF THE DANGER
ZONE DUE TO TSUNAMI CURRENTS**

submitted to the

Puerto Rico Seismic Network as part of the Puerto Rico Component of
the National Tsunami Hazard Mitigation Program

by

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Figure 5 – Google Earth image showing the maximum tsunami current speeds (knots) for both local and regional tsunamis, and the no damage envelope curve based on the 150 m depth isobath.

Location	Distance (nm)¹	Azimuth
San Juan: Entrance to San Juan Bay	1.2	North
Arecibo: tip of breakwater	1.	North
Aguadilla: tip of breakwater	1.2	Northwest
Rincon: Black Eagle Marina	0.7	Southwest
Mayaguez: west end of the port dock	2.7	West
Cabo Rojo: entrance to Puerto Real Bay	8.3	Northwest
Cabo Rojo: from the Boqueron Village	10.8	Southwest
Lajas: La Parguera nautical club	5.6	South
Guanica: entrance to the bay	2.7	Southeast
Guayanilla: Punta Gotay at entrance to the Guayanilla Bay	1.4	South
Ponce: from Club Nautico	2.4	Southwest
Bahía de Jobos, Aguirre: from Cayos de Barca	5.3	South
Bahia de Yabucoa: from entrance	1.5	Southeast
Ceiba: from entrance to Roosevelt Roads Bay	8	Southwest
Fajardo: north from Isleta Marina	8.5	North
Culebra: from entrance to Ensenada Onda	10.6	Southeast
Vieques: from Esperanza	2	Southwest
Vieques: from Isabel Segunda	13	West and then southwest

1 – These are approximate straight line distances

**ASSESSMENT OF THE TSUNAMI-INDUCED TSUNAMI HAZARD
FOR SAN JUAN BAY, PUERTO RICO**

Report Submitted to

**Puerto Rico Component of the USA National Tsunami Hazard Mitigation
Program**

and the

Puerto Rico Seismic Network

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Figure 1 – Google Earth view of San Juan Bay. The locations where time series were measured are shown by the yellow pins. Geographical coordinates are given in Table 1.

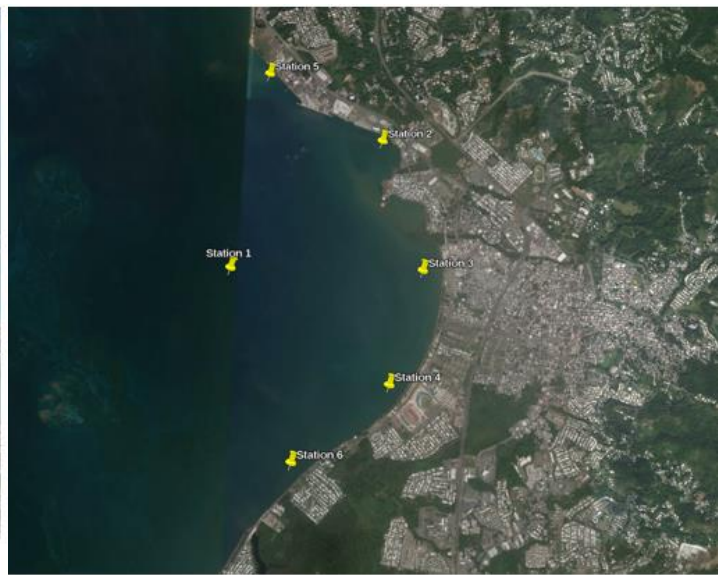


Figure 1 – Google Earth view of Mayaguez Bay. The locations where time series were measured are shown by the yellow pins. Geographical coordinates are given in Table 1.



Figure 1 – Google Earth view of Ponce Bay. The locations where time series were measured are shown by the yellow pins. Geographical coordinates are given in Table 1.



Figure 1: Google Earth image of the area under study. The stations found in the report are presented using yellow pins. Time series are given for each one.

LOCATIONS UP TO NOW



Figure 1



Figure 2



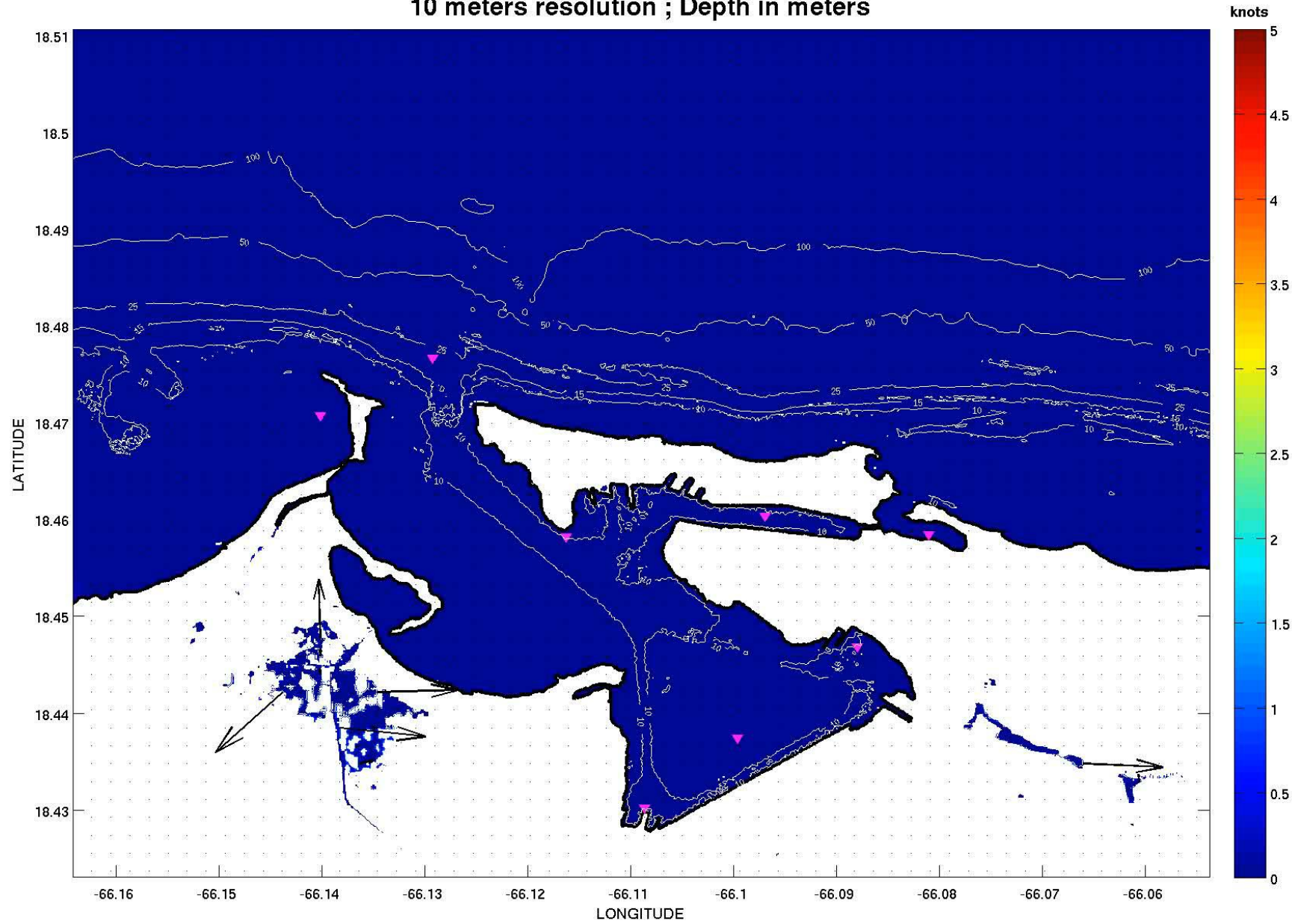
Figure 3

Figure 1-3: Google earth image of the area under study. The time series stations found in the report are presented using yellow pins.

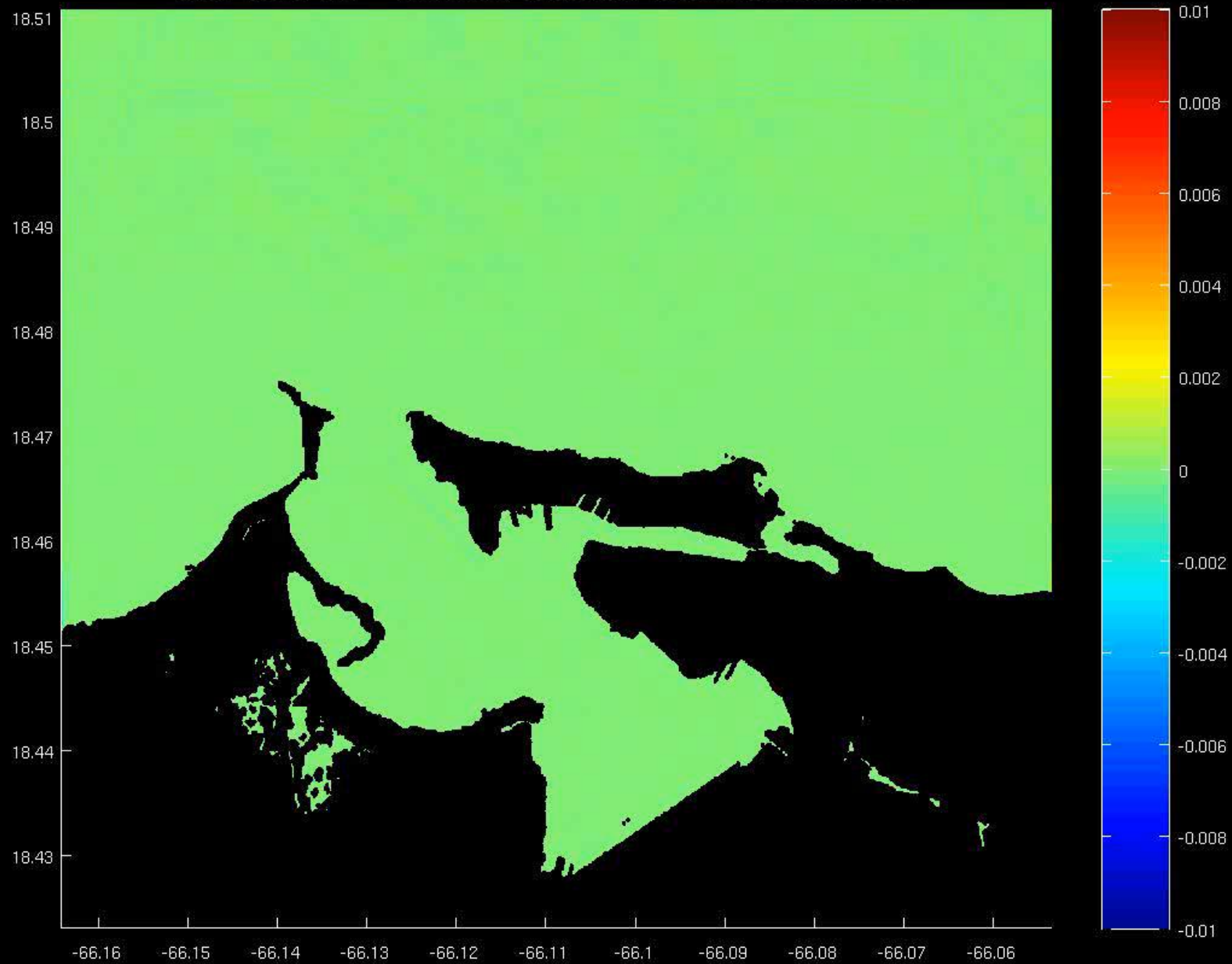
Local Tsunami Current Speed Hazard Zones - San Juan Bay - FEMA Scenario

Snapshot # 1; Hour: 0.0045333

10 meters resolution ; Depth in meters



Time since EQ = 00:00:16 ; Tsunami Current Vorticity in s^{-1}



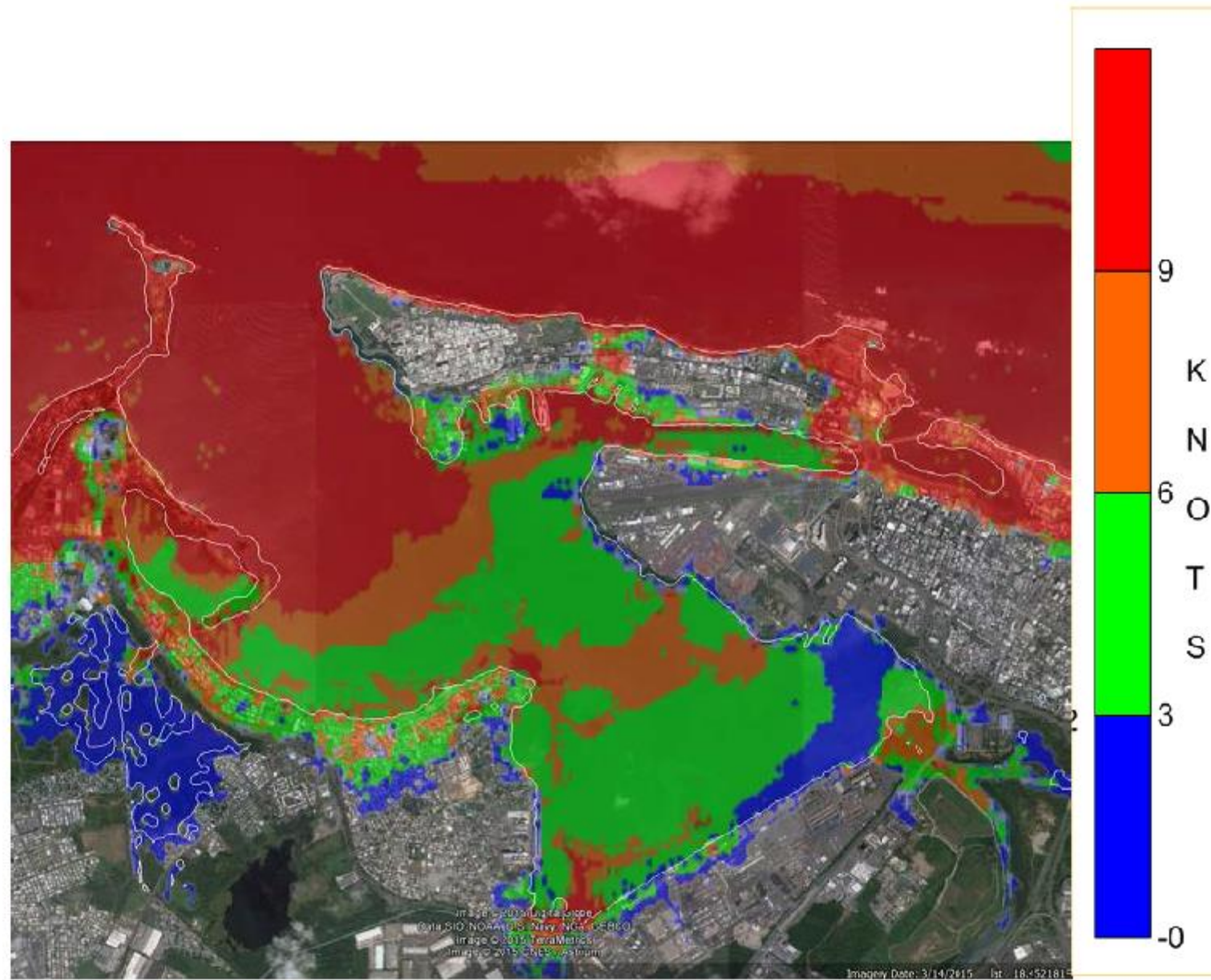


Figure 6 – Maximum tsunami current speed zones for the composite of 320 tsunami simulations.

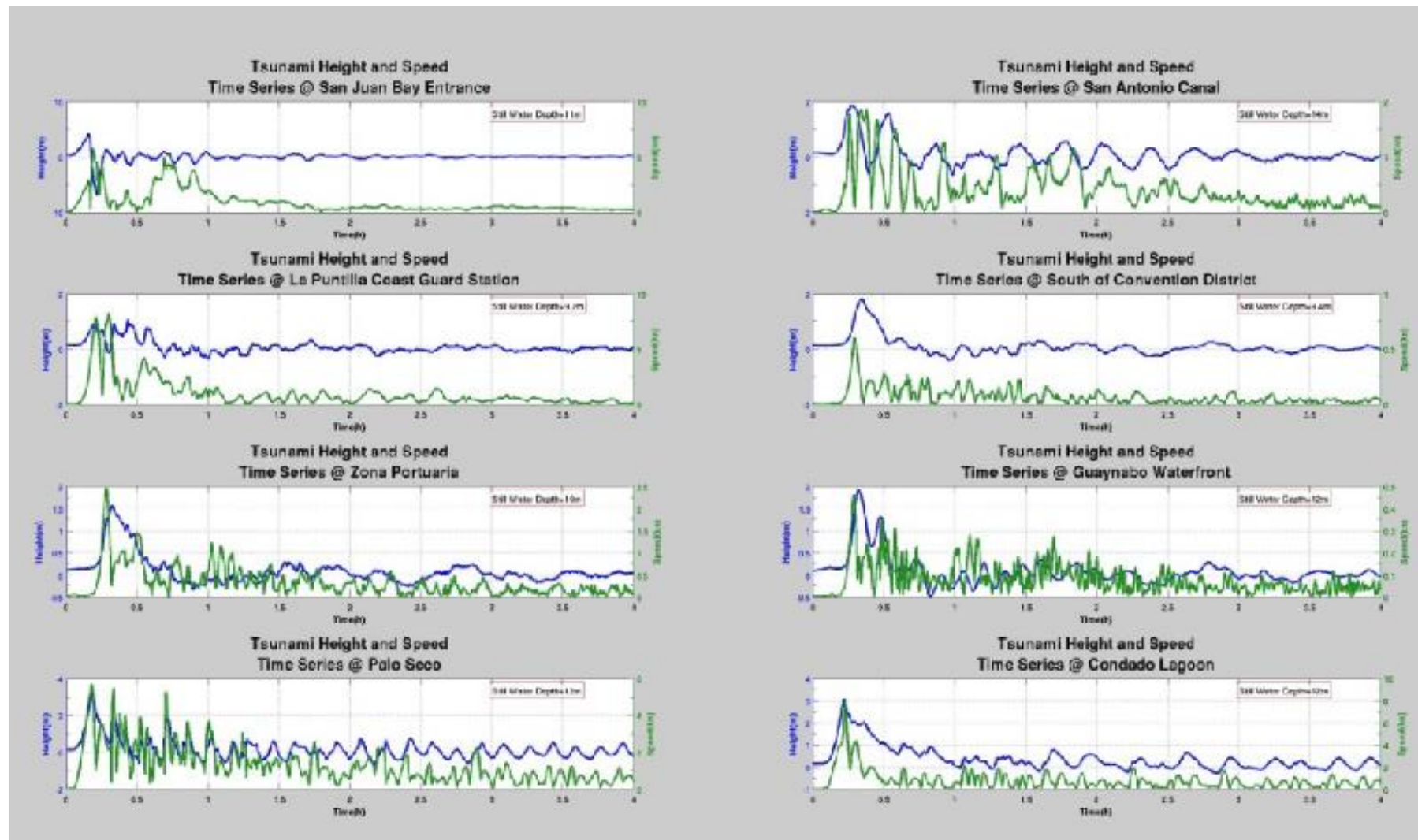


Figure 11 – Tsunami wave height relative to MSL (blue) and tsunami current speeds (green), at stations shown in Figure 1. Grid resolution is 10 m.

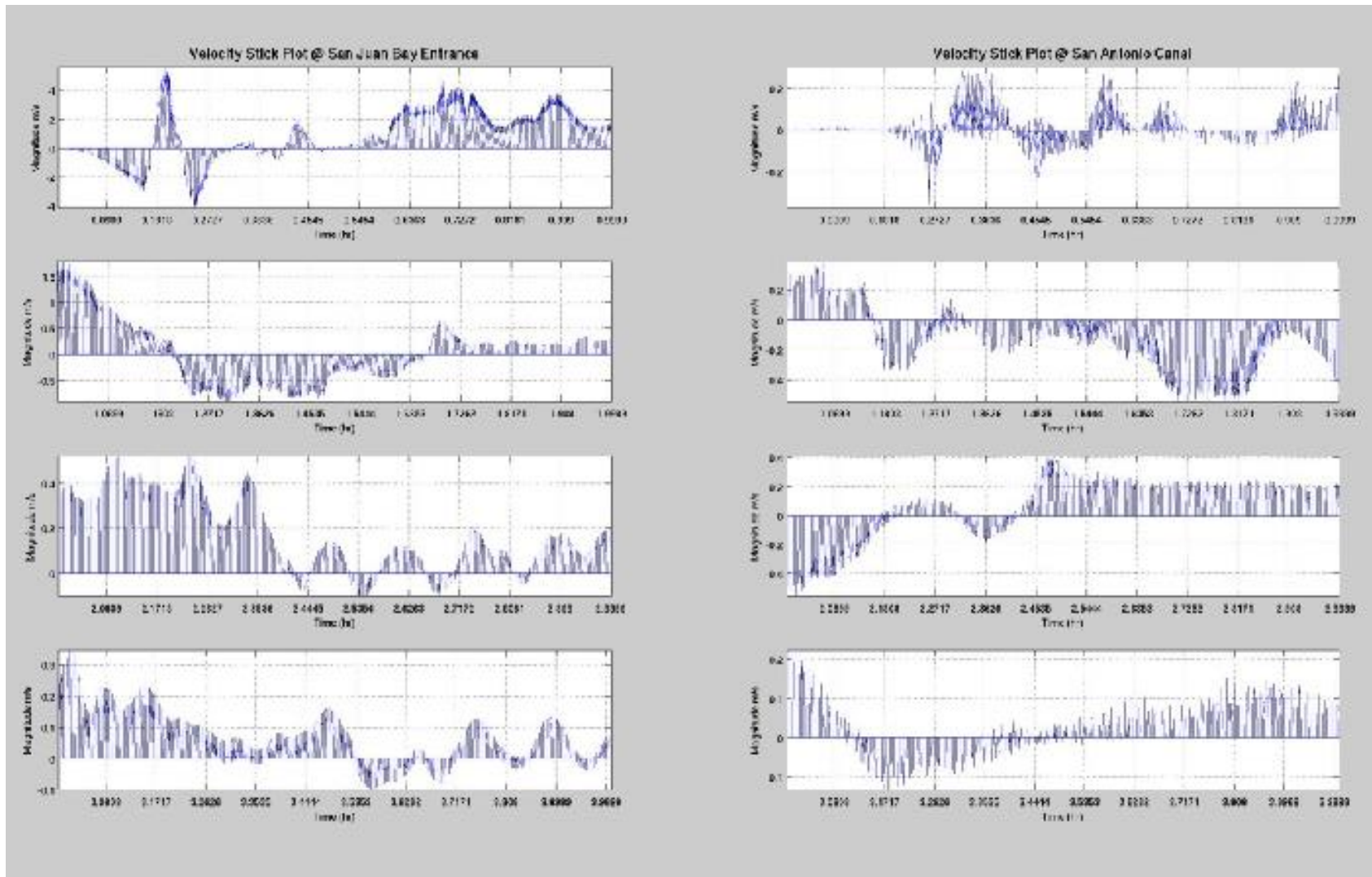


Figure 12 - Stick plots of tsunami current speeds at Stations 1 - San Juan Bay Entrance (left column) and 2 - San Antonio Canal (right column).

Minimum Water Depth - 10 meters resolution

Minimum depth = 0.59 m

Location (-66.0891, 18.4566)

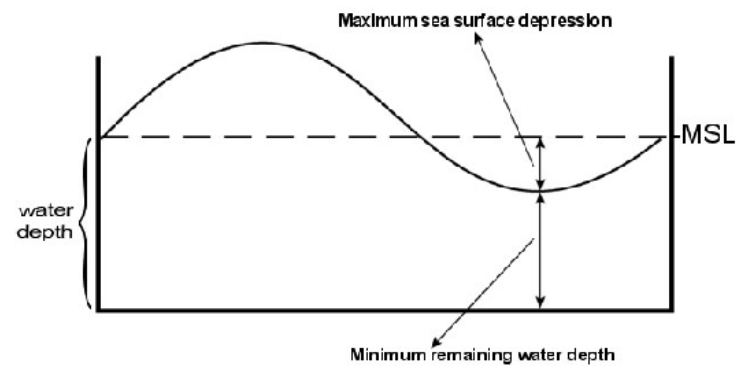
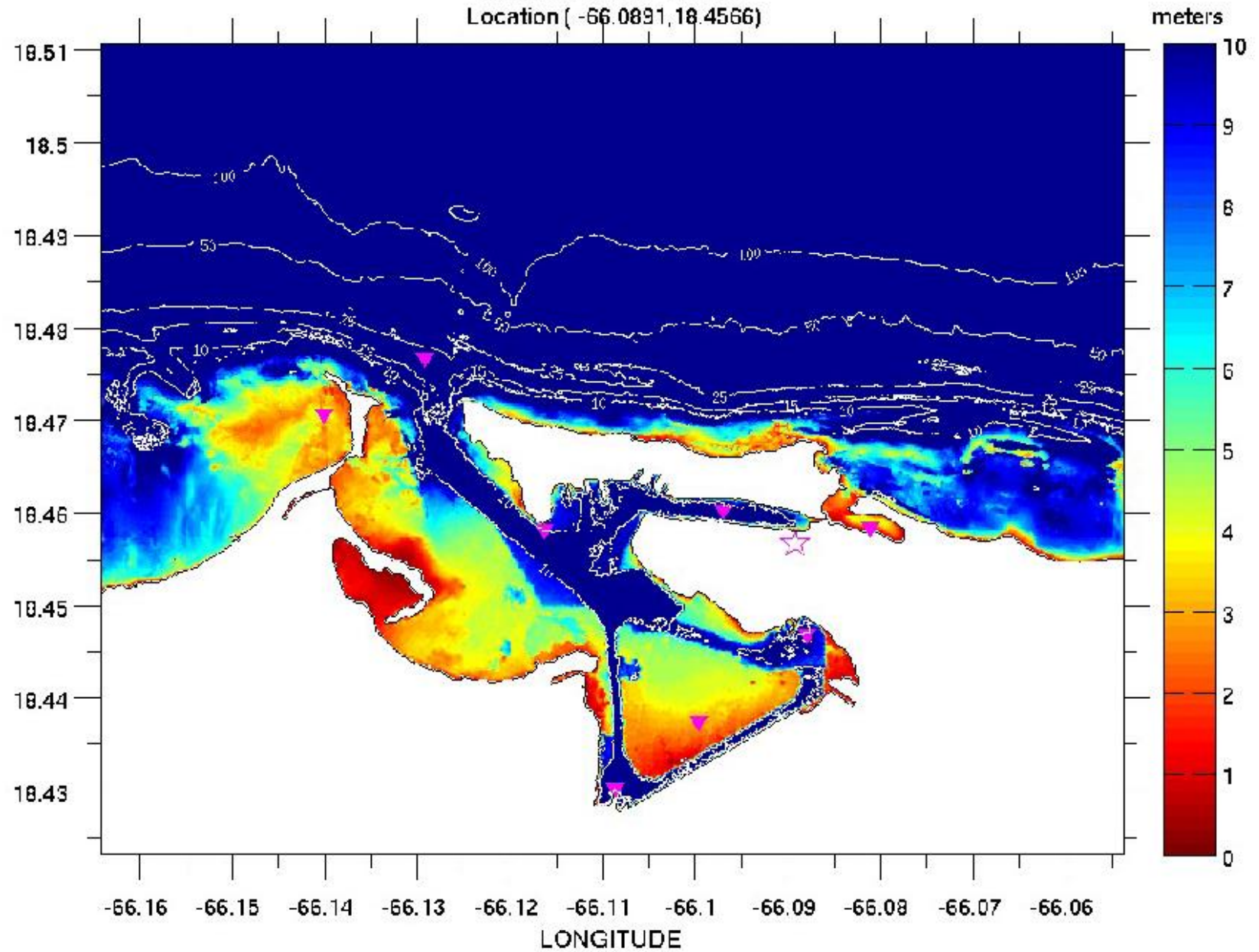


Figure 17 - Schematic of how to evaluate the minimum remaining water depth at each computational node. Minimum remaining water depth = MSL water depth - maximum sea surface depression.



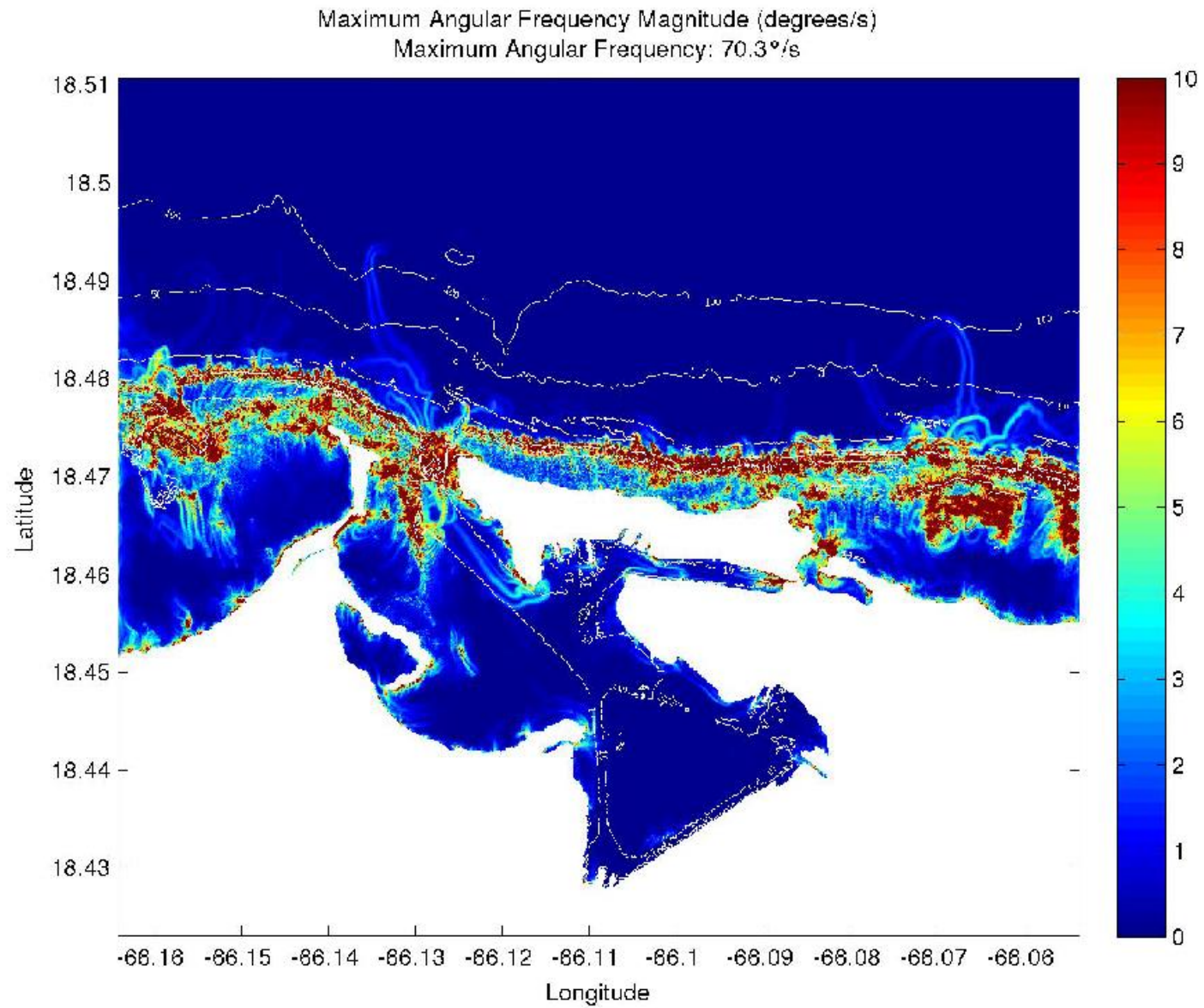
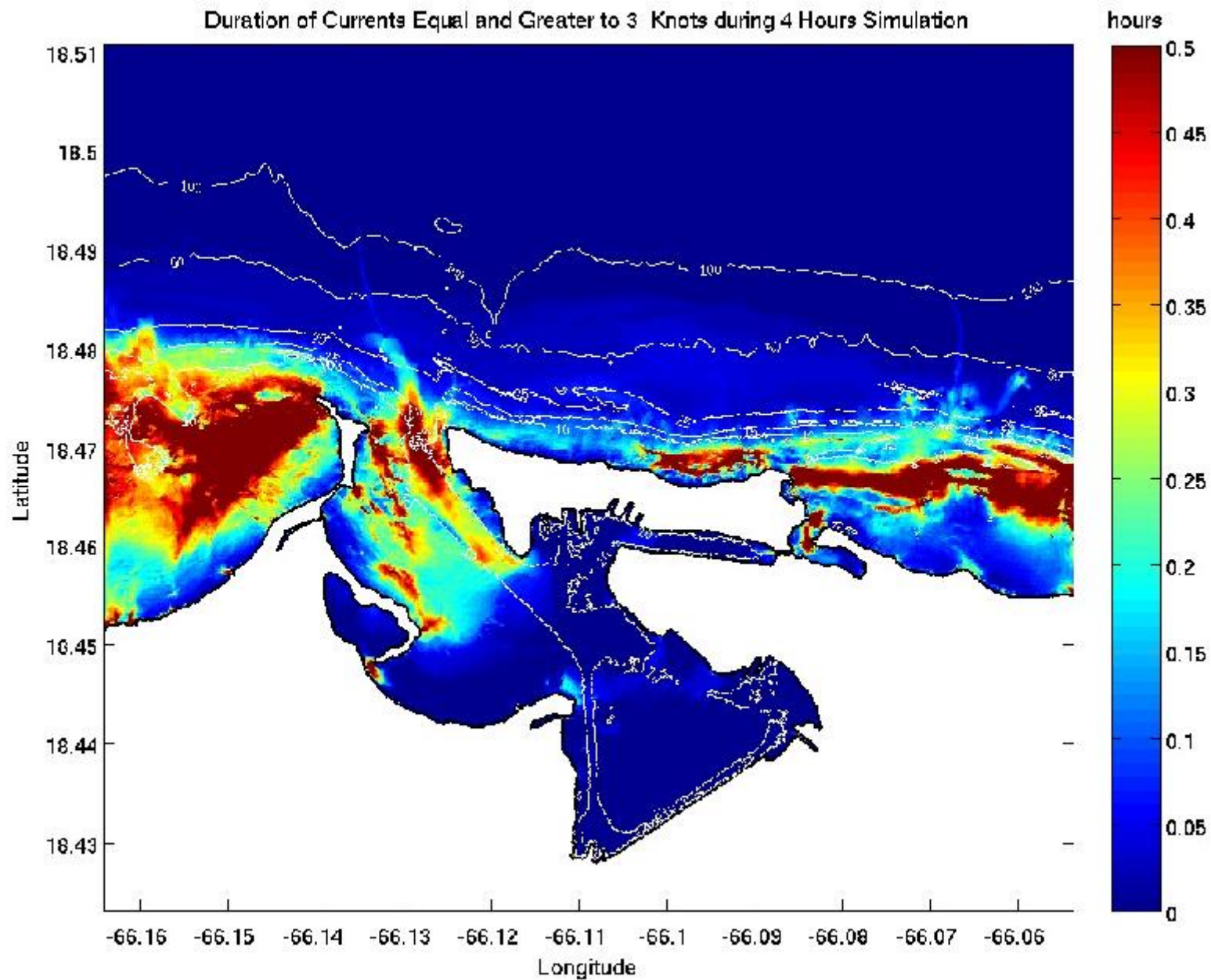
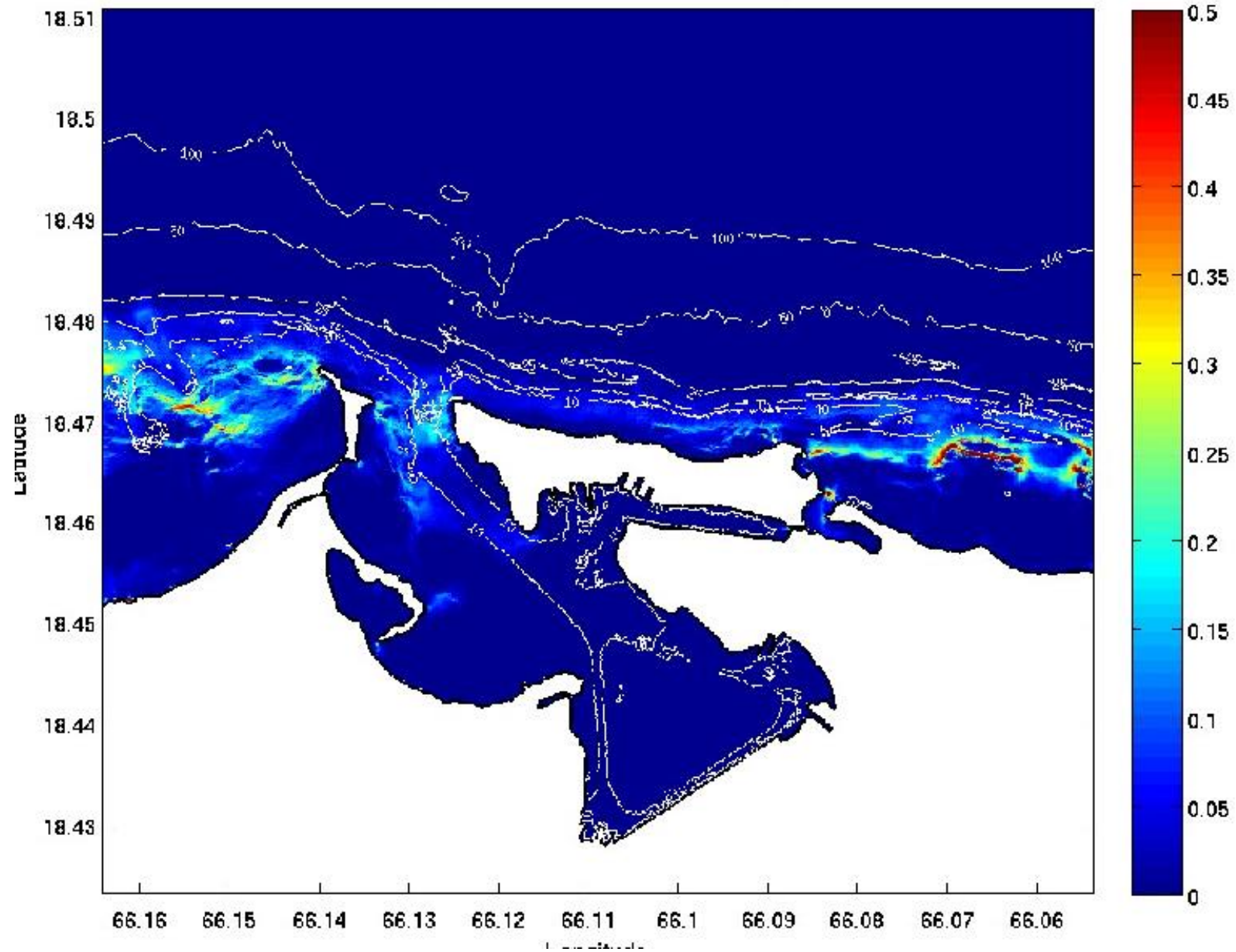


Figure 20 – Figure showing the magnitude of the maximum angular frequency of the eddies induced by the tsunami. Grid resolution is 10 meters.

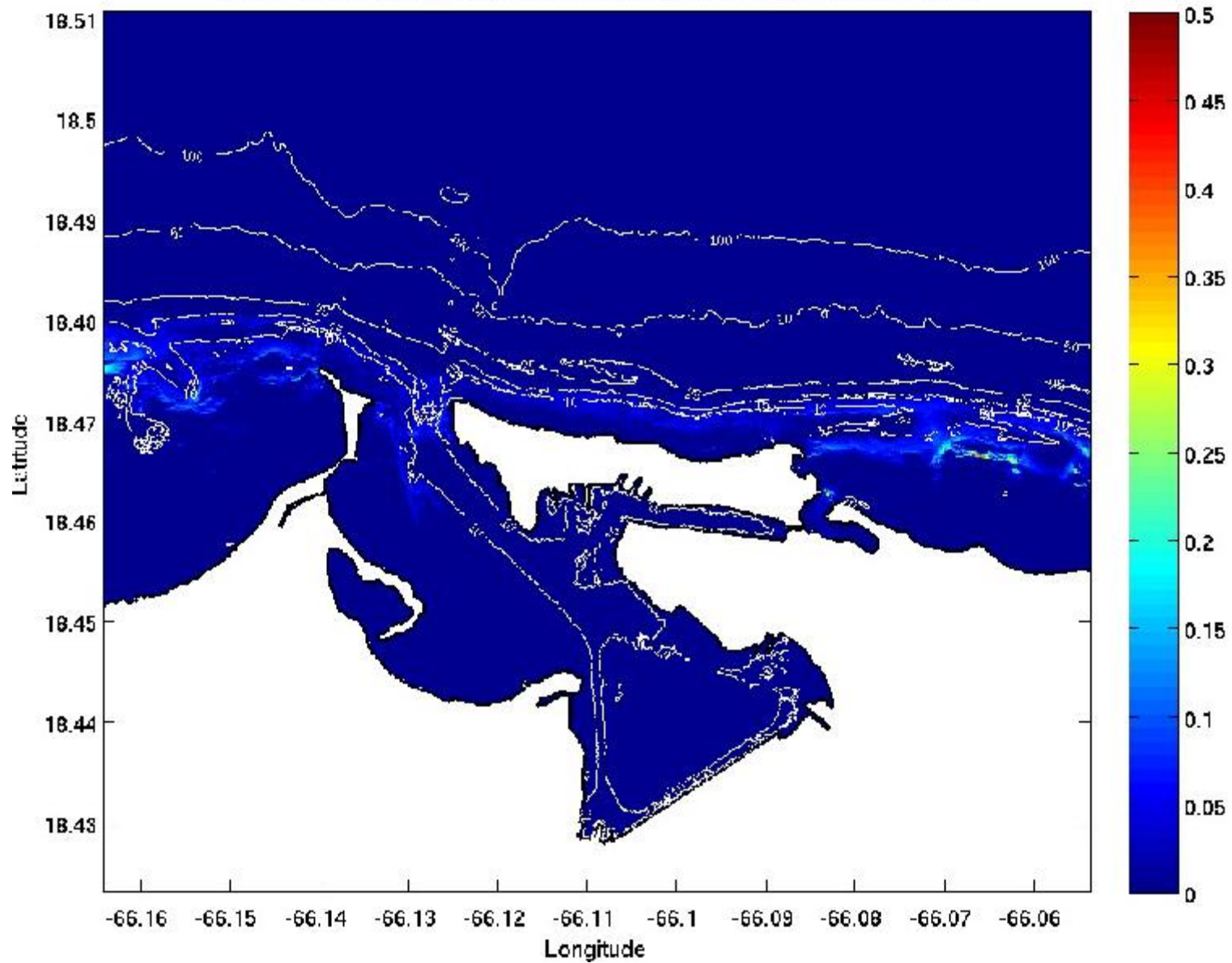
Duration of Currents Equal and Greater to 3 Knots during 4 Hours Simulation



Duration of Currents Equal and Greater to 6 Knots during 4 Hours Simulation



Duration of Currents Equal and Greater to 9 Knots during 4 Hours Simulation



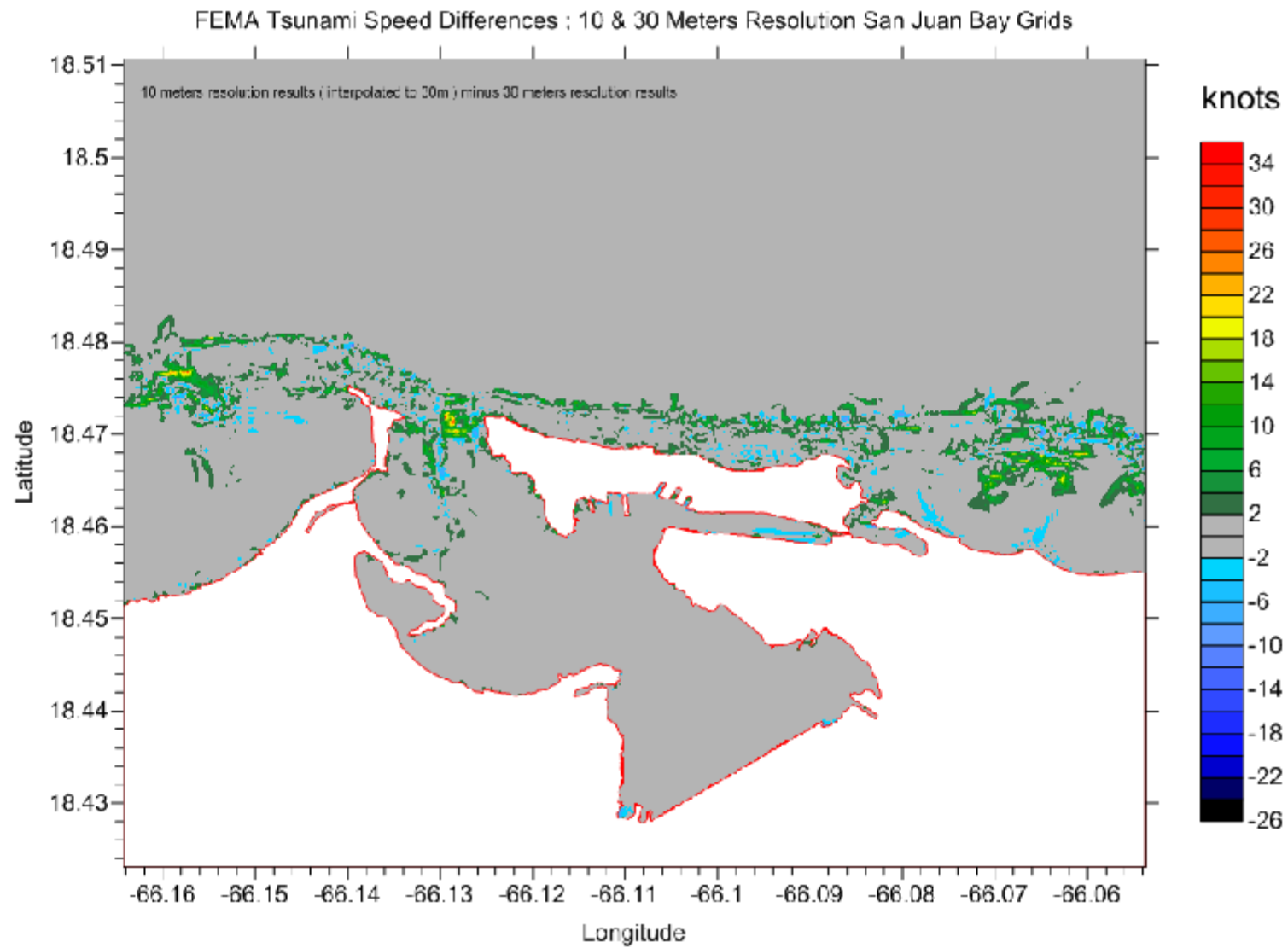


Figure 31 - Tsunami current speed differences between 10 and 30 meters resolutions. See text for explanation.