Harbor Vulnerability Analysis

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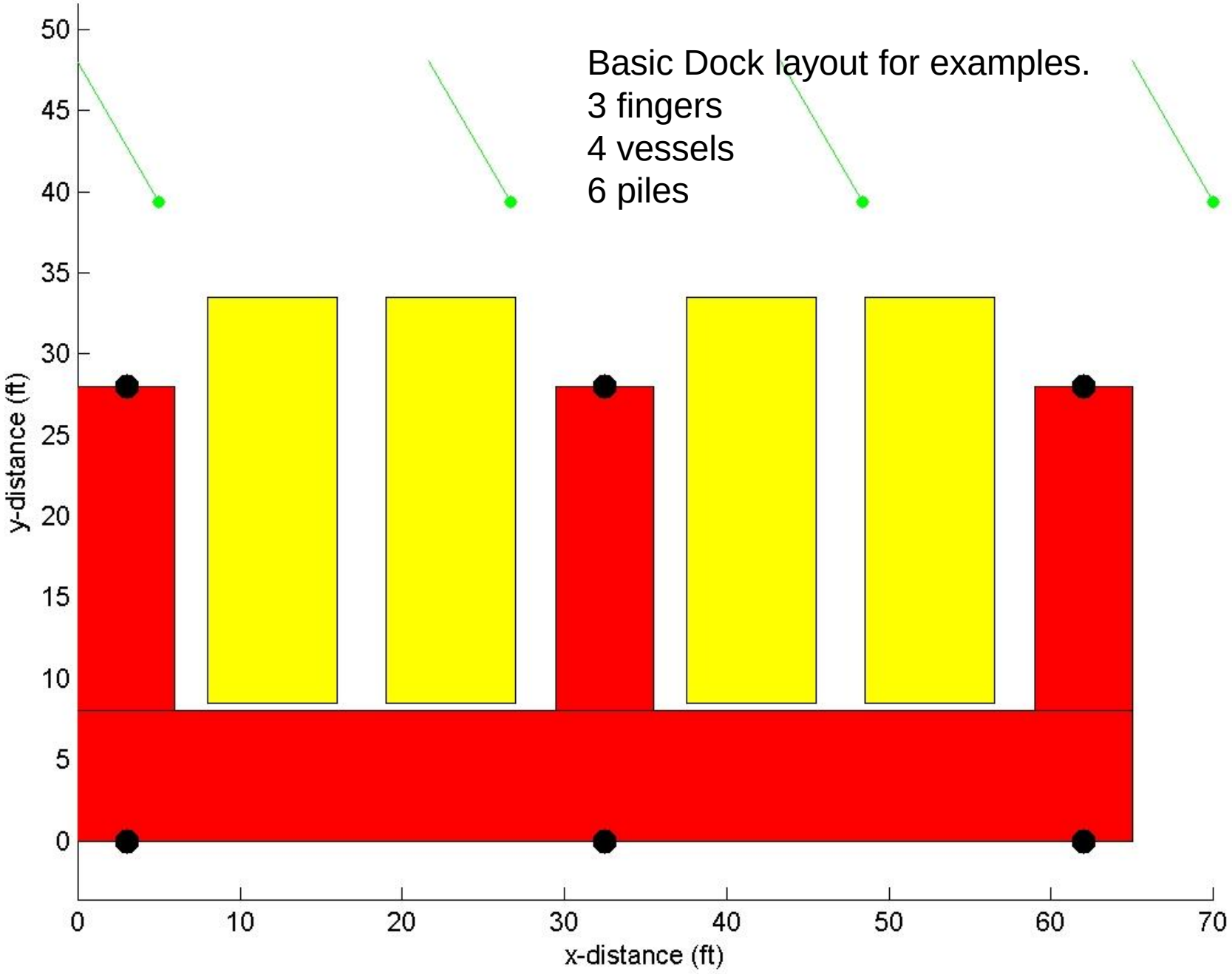
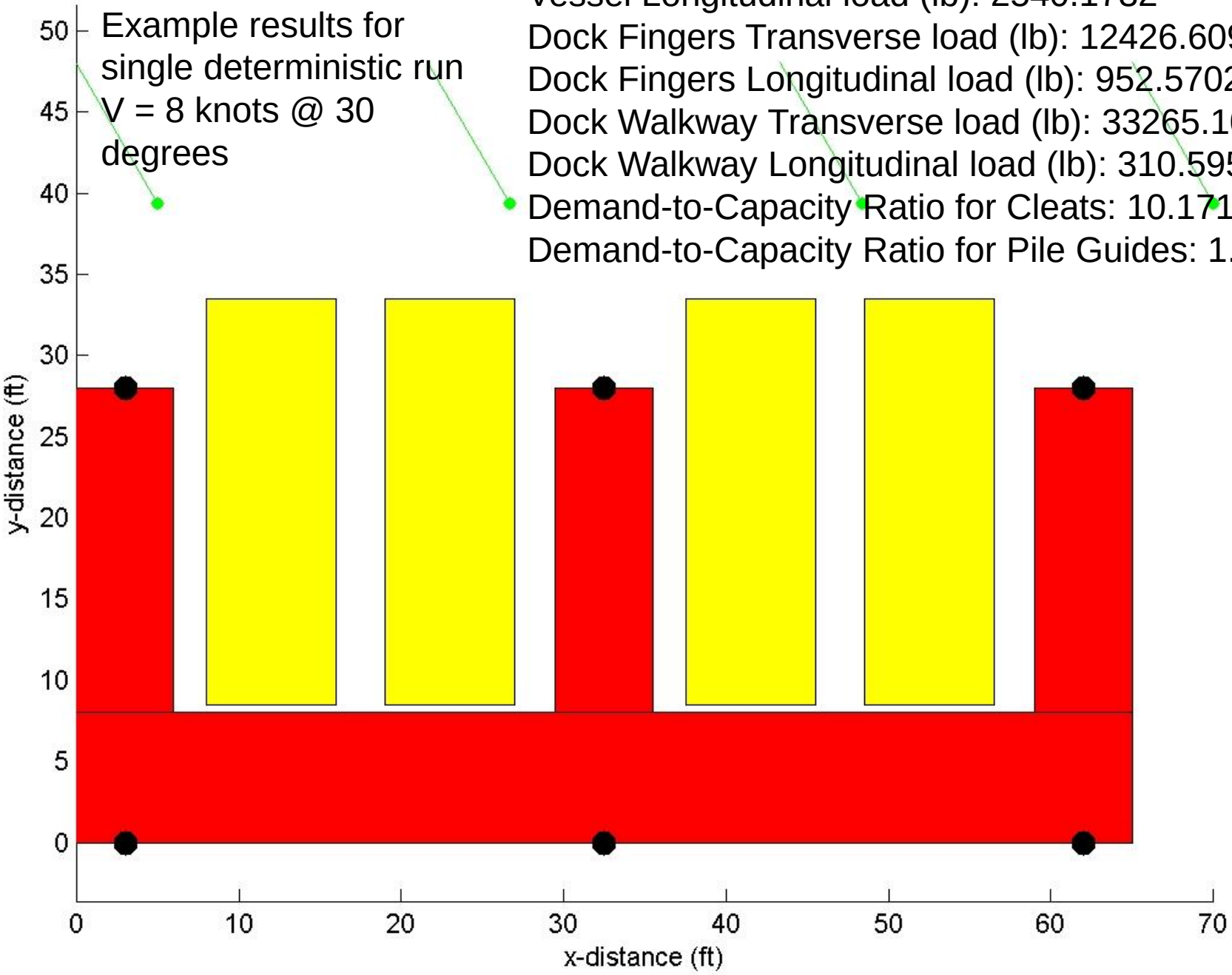
Harbor Vulnerability Analysis

- **Examine different components in harbor setting**
  - **Cleats**
  - **Pile guides**
  - **Navigation Buoys**
  - **Single Point Moorings**
  - **Large vessel chain anchors**
- **For each component:**
  - **Develop a method to determine both the demand and capacity of the component for a deterministic forcing**
    - **Use only the maximum simulated flow speed,**
    - **Not yet accounting for accelerations / flow reversals**
  - **Demand and capacity calculations are functions of a number of parameters that are not well known or known to be variable during an event**
    - **Specific gravity of water, current angle, water depth, number of vessels**
  - **Most importantly, the capacity of the component will be a strong function of its condition**
    - **To perform this analysis, need an inventory of component condition!**

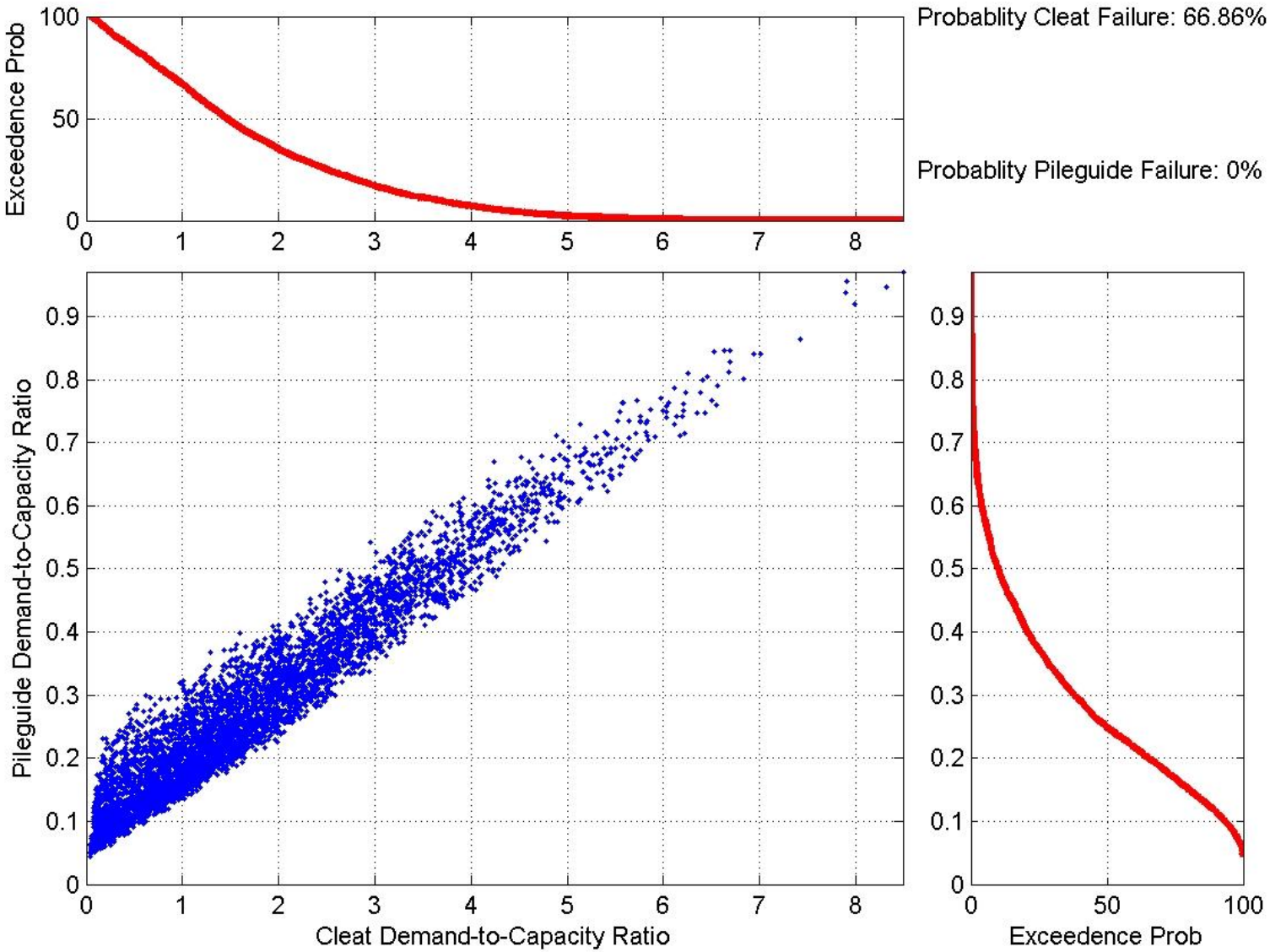
Example Application – Cleat and Pileguide Analysis

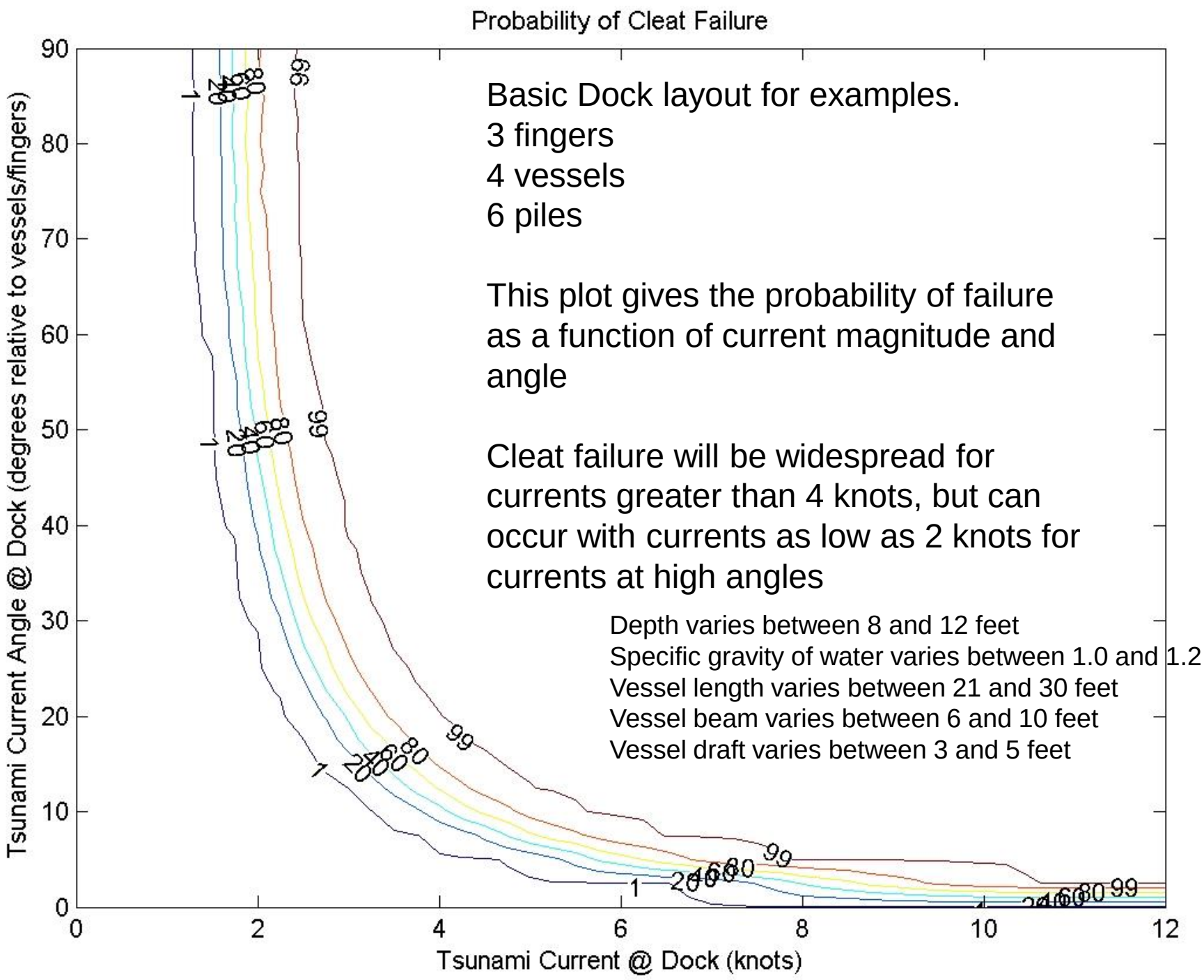


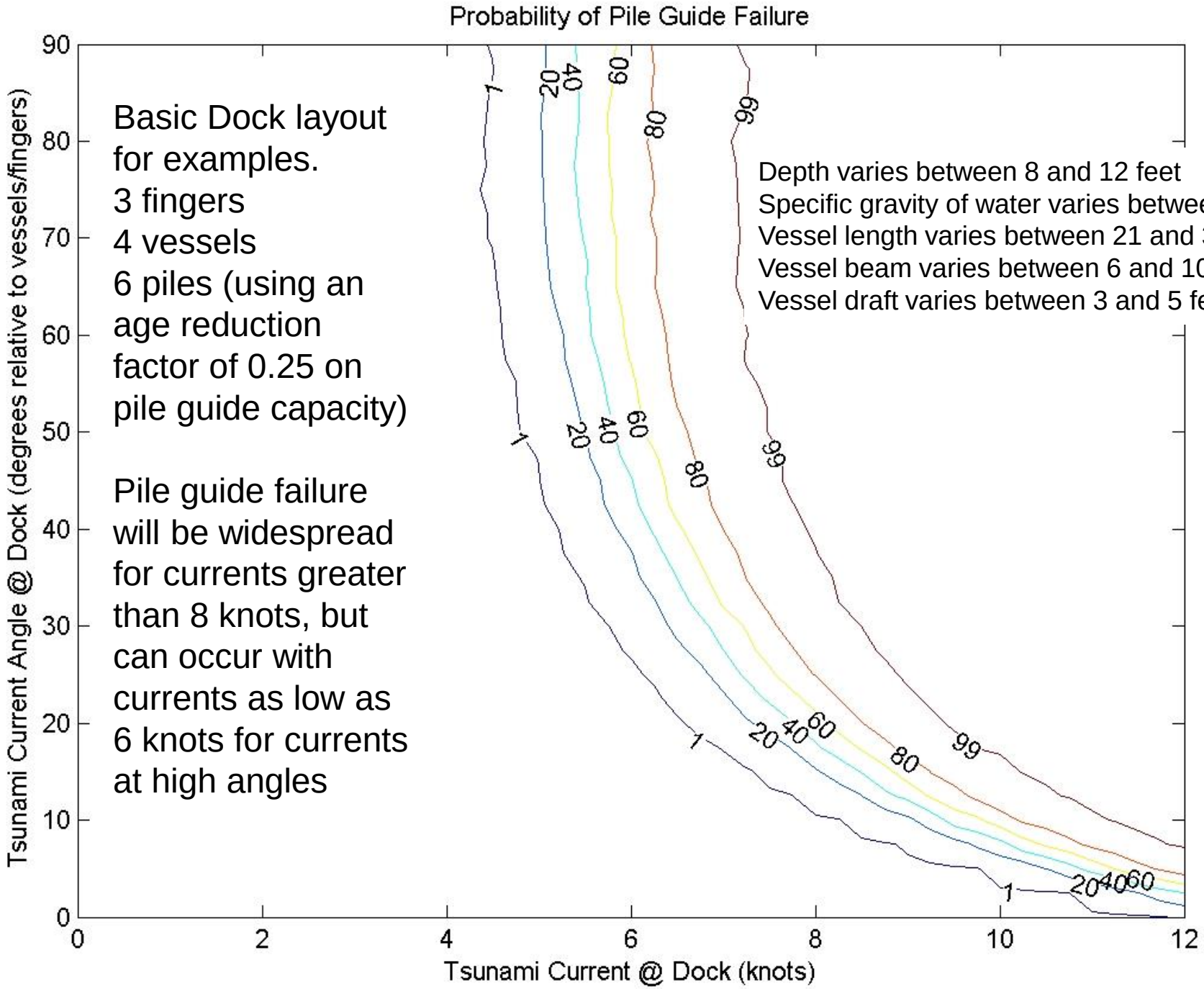

Example results for single deterministic run V = 8 knots @ 30 degrees
Vessel Transverse load (lb): 97609.7301
Vessel Longitudinal load (lb): 2540.1732
Dock Fingers Transverse load (lb): 12426.6098
Dock Fingers Longitudinal load (lb): 952.5702
Dock Walkway Transverse load (lb): 33265.1007
Dock Walkway Longitudinal load (lb): 310.5951
Demand-to-Capacity Ratio for Cleats: 10.1711
Demand-to-Capacity Ratio for Pile Guides: 1.3273
y-distance (ft)
x-distance (ft)
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70

Basic Dock layout for examples.
3 fingers
4 vessels
6 piles

Current = 4.5 knots
Angle = 15 degrees
Depth varies between 8 and 12 feet
Specific gravity of water varies between 1.0 and 1.2
Vessel length varies between 21 and 30 feet
Vessel beam varies between 6 and 10 feet
Vessel draft varies between 3 and 5 feet

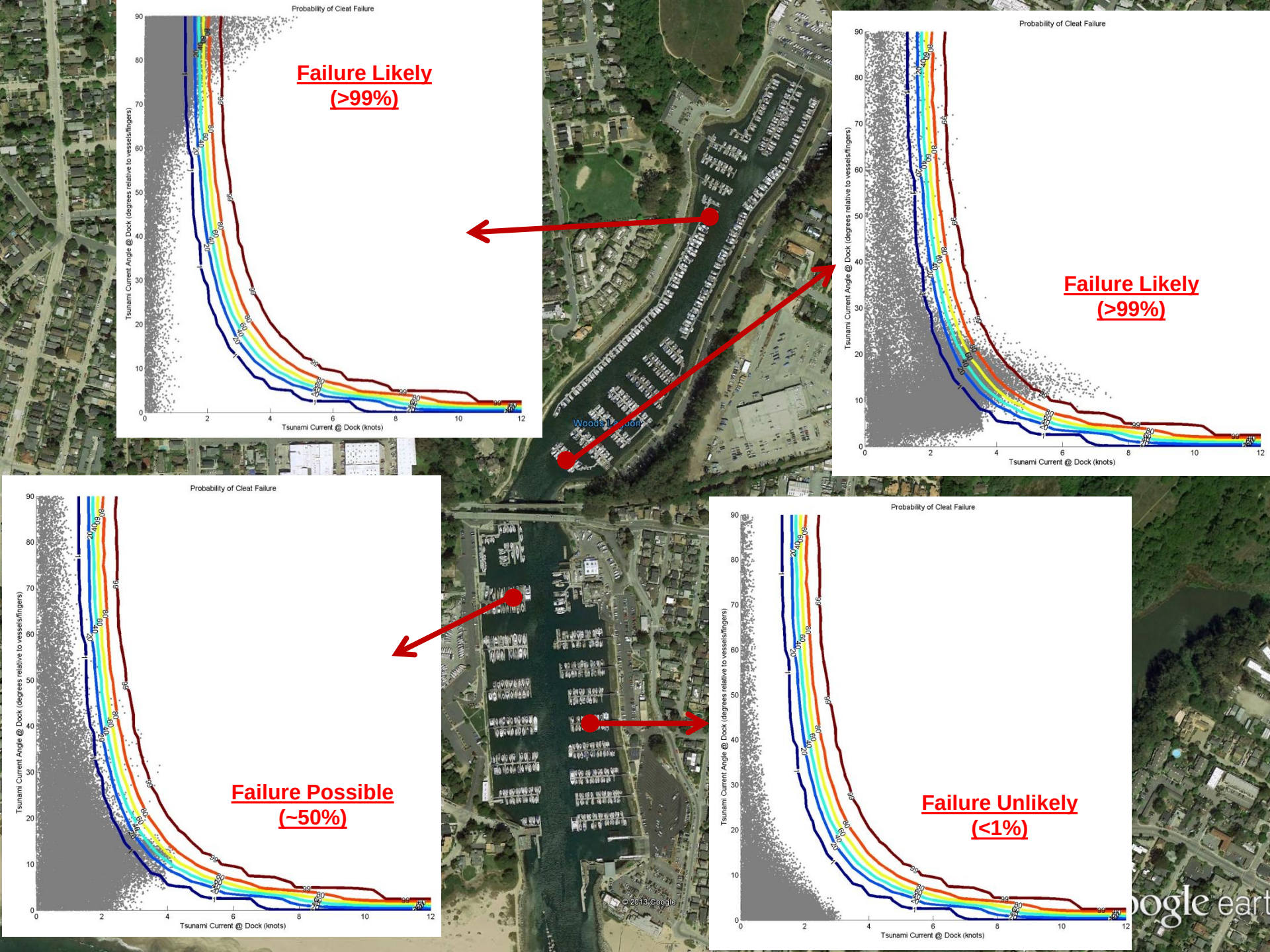



Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
1
20
40
60
80
99
Basic Dock layout for examples.
3 fingers
4 vessels
6 piles
This plot gives the probability of failure as a function of current magnitude and angle
Cleat failure will be widespread for currents greater than 4 knots, but can occur with currents as low as 2 knots for currents at high angles
Depth varies between 8 and 12 feet
Specific gravity of water varies between 1.0 and 1.2
Vessel length varies between 21 and 30 feet
Vessel beam varies between 6 and 10 feet
Vessel draft varies between 3 and 5 feet


Probability of Pile Guide Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
1
20
40
60
80
99
Basic Dock layout for examples.
3 fingers
4 vessels
6 piles (using an age reduction factor of 0.25 on pile guide capacity)
Pile guide failure will be widespread for currents greater than 8 knots, but can occur with currents as low as 6 knots for currents at high angles
Depth varies between 8 and 12 feet
Specific gravity of water varies between 1.0 and
Vessel length varies between 21 and 30 feet
Vessel beam varies between 6 and 10 feet
Vessel draft varies between 3 and 5 feet

Harbor Vulnerability Analysis

- **Scenario-Based Failure Probability**


Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
Failure Likely (>99%)
Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
Failure Likely (>99%)
Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
Failure Possible (~50%)
Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
Failure Unlikely (<1%)
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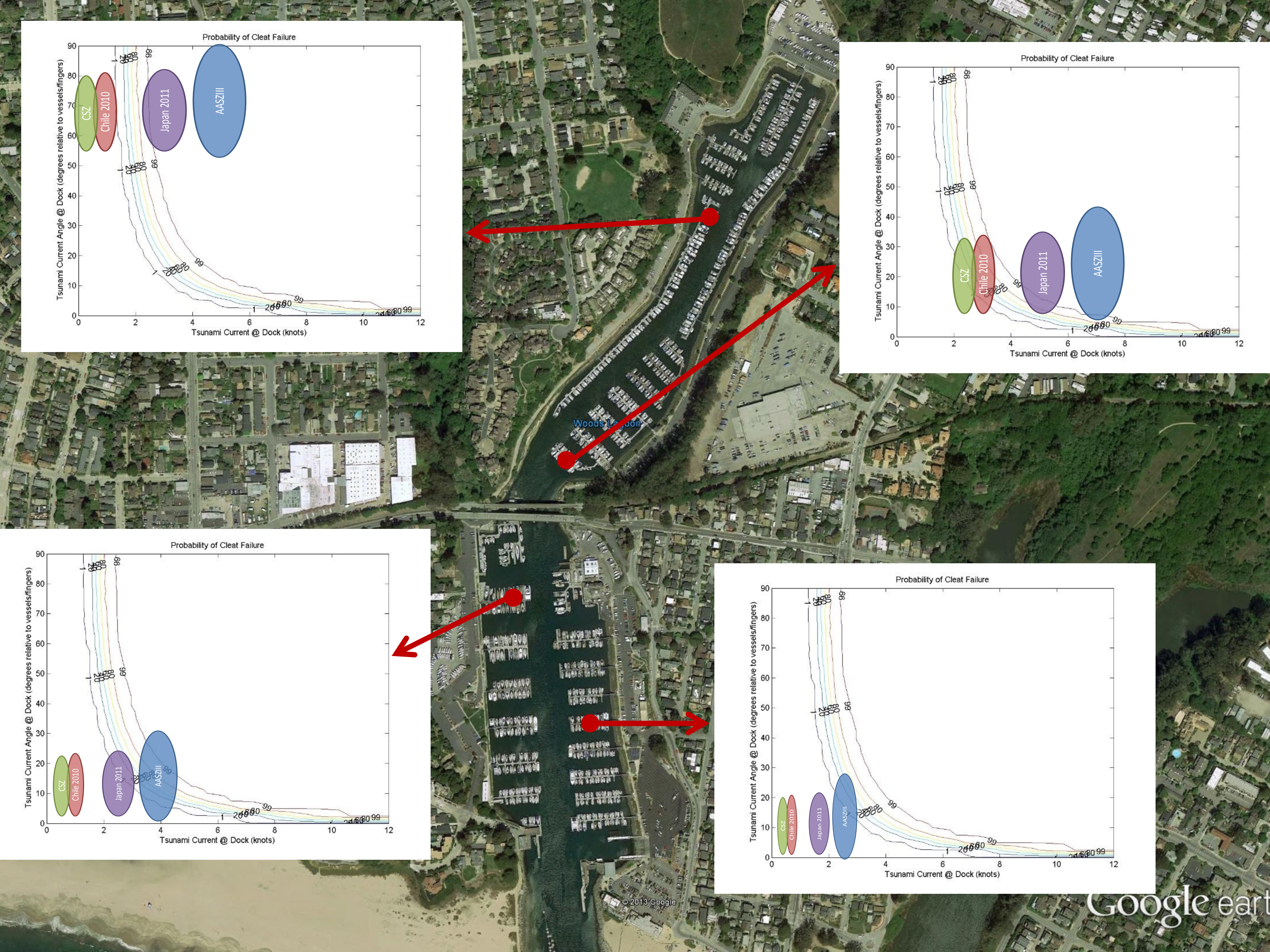

Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
Woods Lagoon
Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
Probability of Cleat Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
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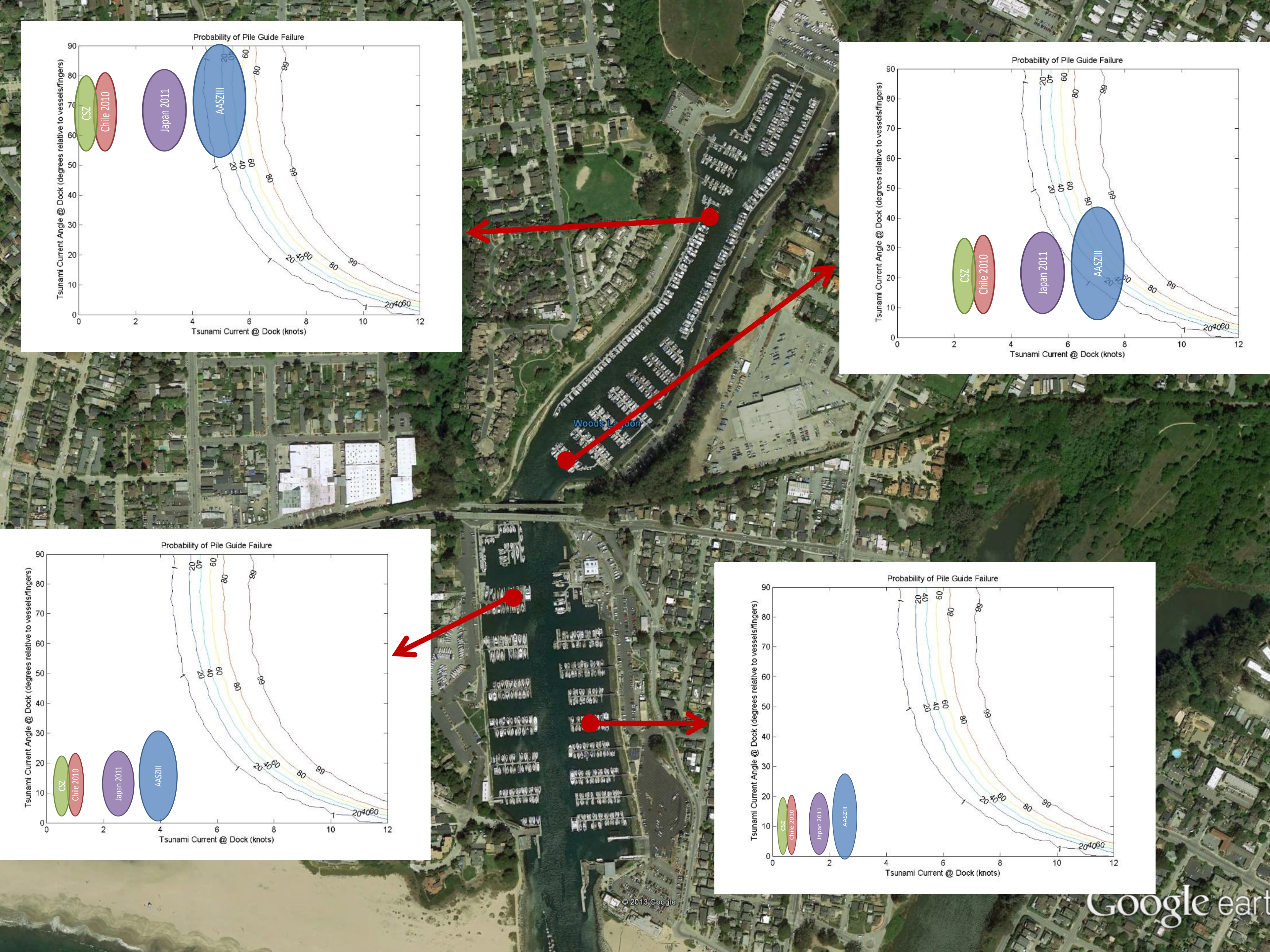
Probability of Pile Guide Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
Probability of Pile Guide Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
Woods Lagoon
Probability of Pile Guide Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
Probability of Pile Guide Failure
Tsunami Current Angle @ Dock (degrees relative to vessels/fingers)
Tsunami Current @ Dock (knots)
CSZ
Chile 2010
Japan 2011
AASZIII
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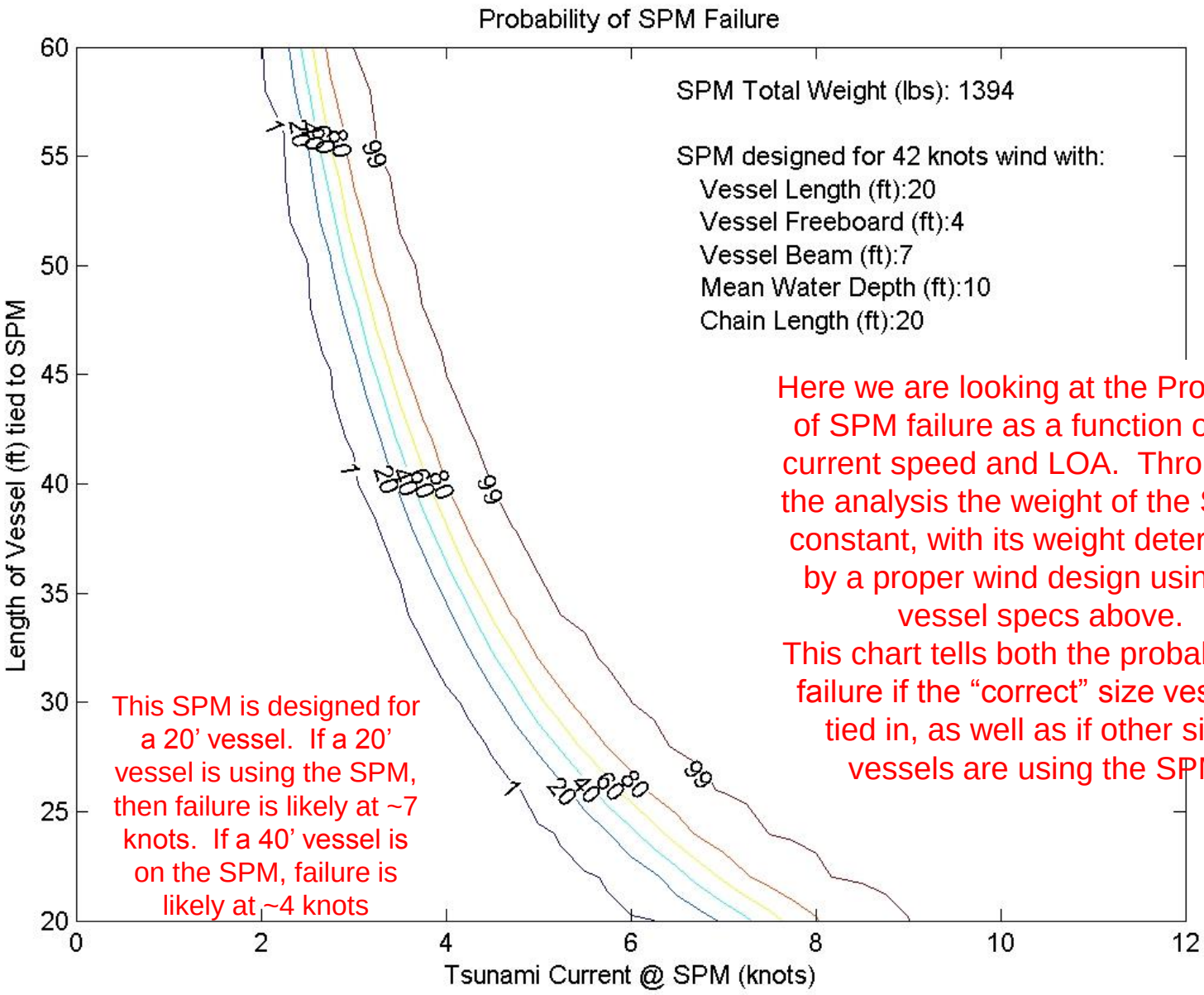
ONGOING WORK

- **Single Point Mooring Failure**



This SPM is designed for a 20' vessel. If a 20' vessel is using the SPM, then failure is likely at ~7 knots. If a 40' vessel is on the SPM, failure is likely at ~4 knots

Here we are looking at the Probability of SPM failure as a function of both current speed and LOA. Throughout the analysis the weight of the SPM is constant, with its weight determined by a proper wind design using the vessel specs above.

This chart tells both the probability of failure if the "correct" size vessel is tied in, as well as if other sized vessels are using the SPM.