

# Communicating Probabilities and Risk

*(and weather)*

**“Medicine is a science of uncertainty  
and an art of probability.”**

-- Sir William Osler (1849-1919)

# What are we certain about?

- “’Tis impossible to be sure of any thing but Death and Taxes,”
  - Christopher Bullock, *The Cobbler of Preston* (1716)
- “Things as certain as death and taxes, can be more firmly believ'd.”
  - Daniel Defoe, *The Political History of the Devil* (1726)
- “Our new Constitution is now established, and has an appearance that promises permanency; but in this world nothing can be said to be certain, except death and taxes.”
  - Benjamin Franklin, letter to Jean-Baptiste Leroy (1789)

“...misunderstanding of probability, may be the greatest of all general impediments to scientific literacy.”

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# Probability



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# Where Communication of Probability Can Go Wrong

- **Single-event probabilities**

- The probability of event X is Y%

- **Conditional probabilities**

- Given event X, the probability of event Y is Z%

- **Relative risks**

- The probability of event X is Y times the probability of event Z

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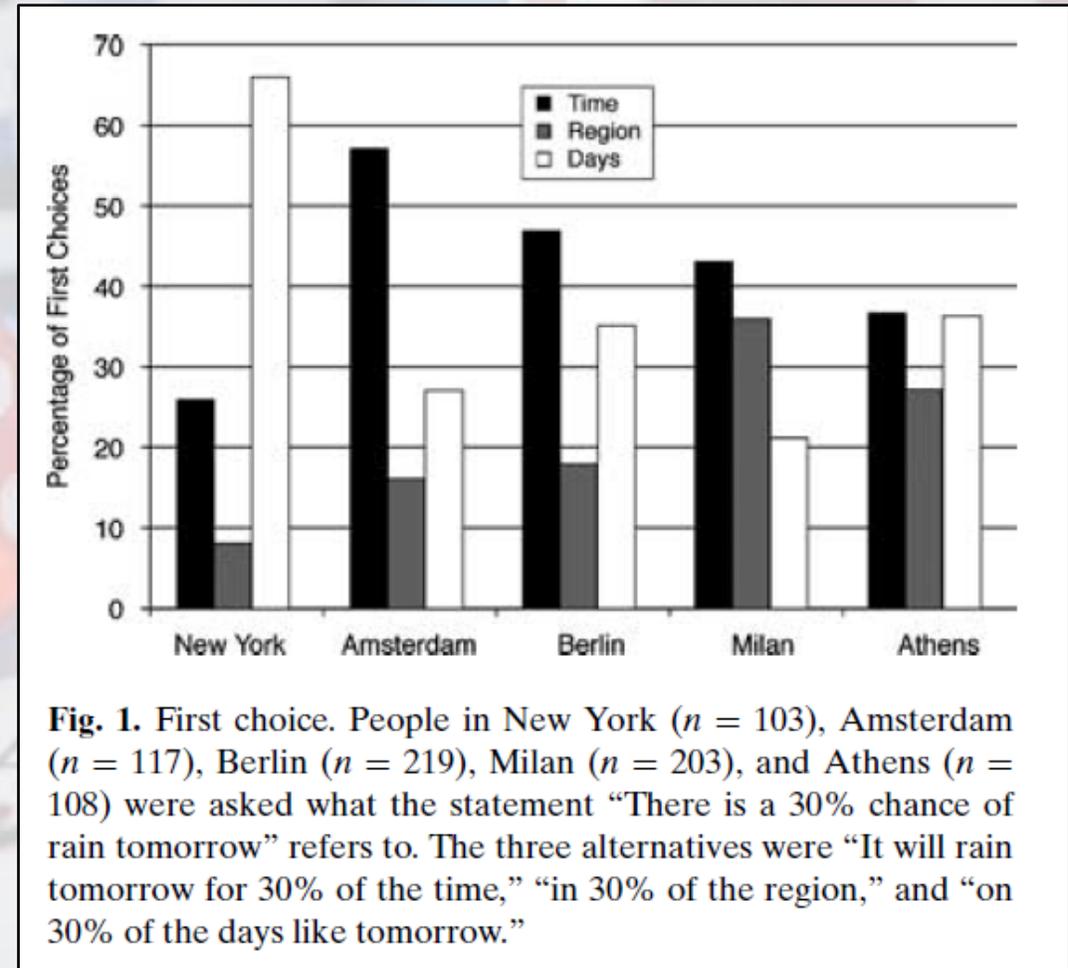
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# “A 30% Chance of Rain Tomorrow”: How Does the Public Understand Probabilistic Weather Forecasts?

Gigerenzer et al. (2005), *Risk Analysis*

## Some “interesting” interpretations:

- 3 out of 10 meteorologists believe it will rain
- If you look up at the sky and see 100 clouds, then 30 of them are black
- If we had 100 lives, it would rain in 30 of these tomorrow



“The excitement that a gambler feels when making a bet is equal to the amount he might win times the probability of winning it.” – Mathematician Blaise Pascal (1623-1662)

# Single-Event Probabilities

“The probability than an event will happen is X percent”

- **Problems arise if there is no stated reference class**
  - e.g., “There is a 30% chance that it will rain tomorrow”
    - 30% of the time? Over what period?
    - 30% of the area? Which area?
    - 30% of the days that are like tomorrow?
    - 30% of meteorologists say so? Do you believe some more than others? 😊
- **Don't allow people to assume the reference class of a probability – tell them (correctly) what it is!**
  - point vs. areal probabilities
  - *“Misunderstandings can be easily reduced if a statement specifying the intended reference class is added.”* – Gigerenzer et al. (2005)

“The laws of probability, so true in general, so fallacious in particular.” – Historian Edward Gibbon (1737-1794)



# Point vs. Areal Probabilities



- What is the probability that the dolphins catch a *specific individual fish* from the bait ball?
- What is the probability that the dolphins catch *any fish* in the bait ball?

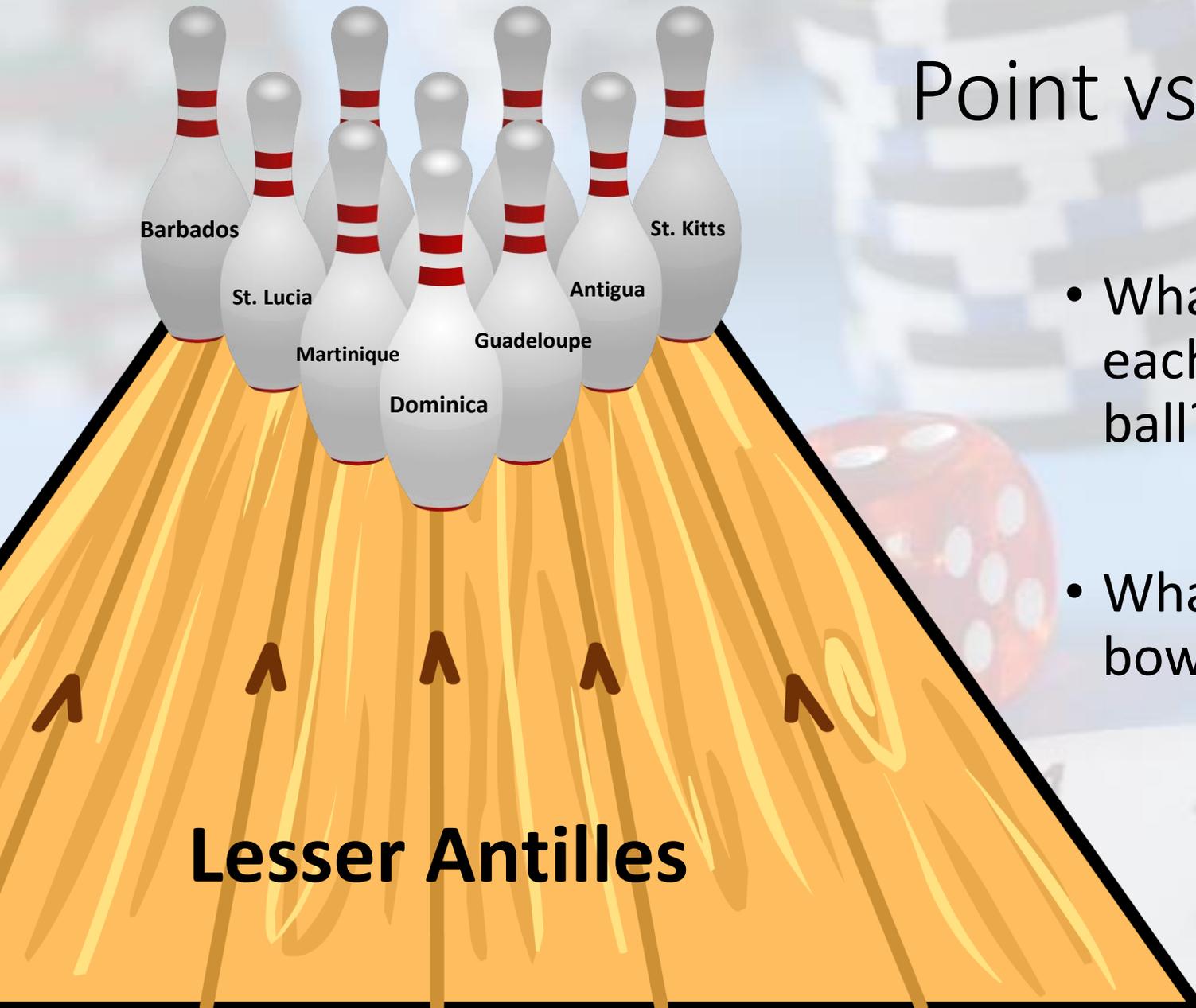
Even though it's a near certainty that the dolphins will catch at least one fish, the bait ball lowers the probability for each individual fish that it will be the one caught.

“Lest men suspect your tale untrue, keep probability in view.” – Poet John Gay (1685-1732)

**JASON BELMONTE**  
ARSENAL

BALL	HOOK
Lucid	9.5
Defiant Soul	9.0
Reign of Power	8.5
IQ Tour Pearl	7.5
The Wrecker	7.5

# Point vs. Areal Probabilities

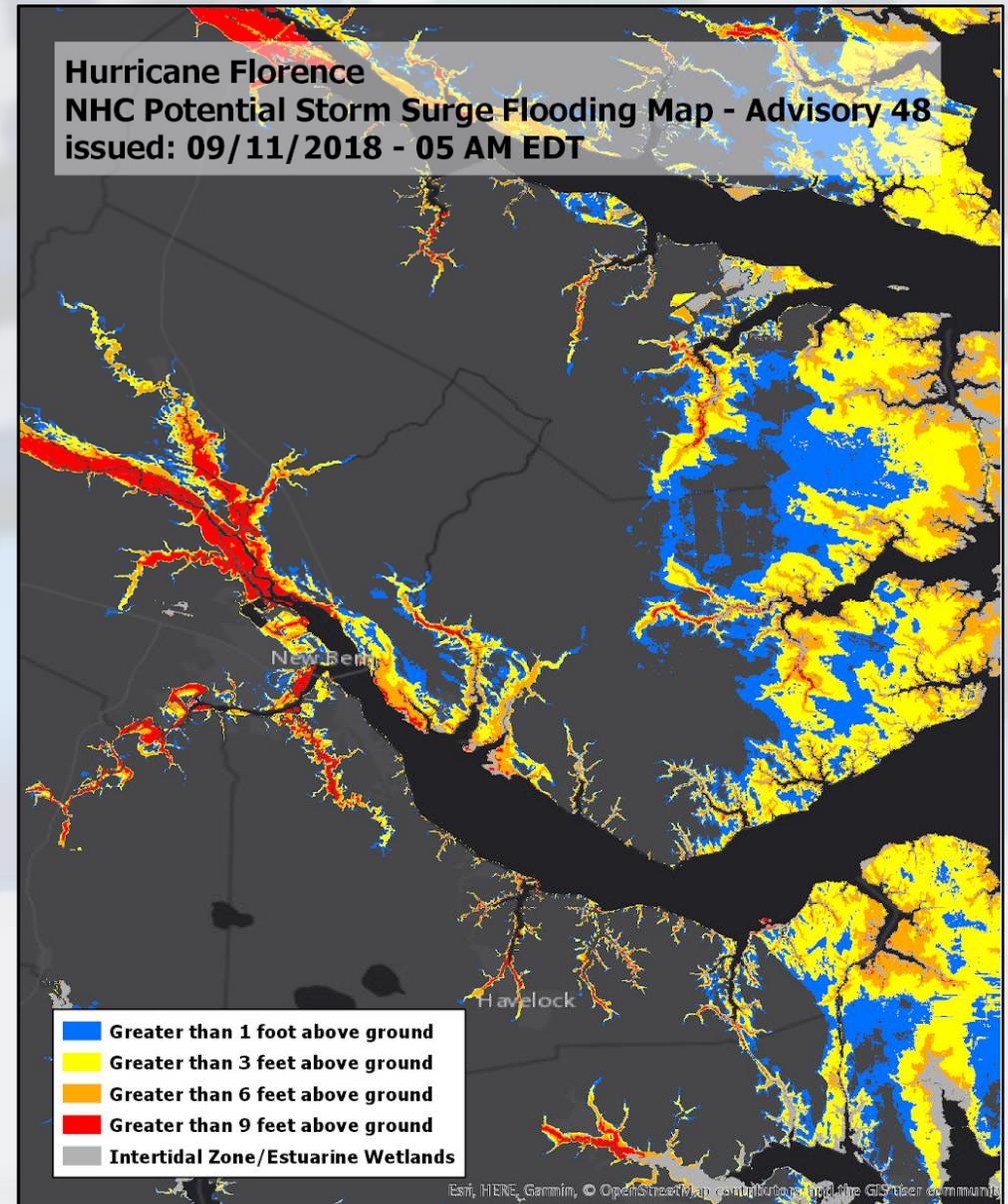
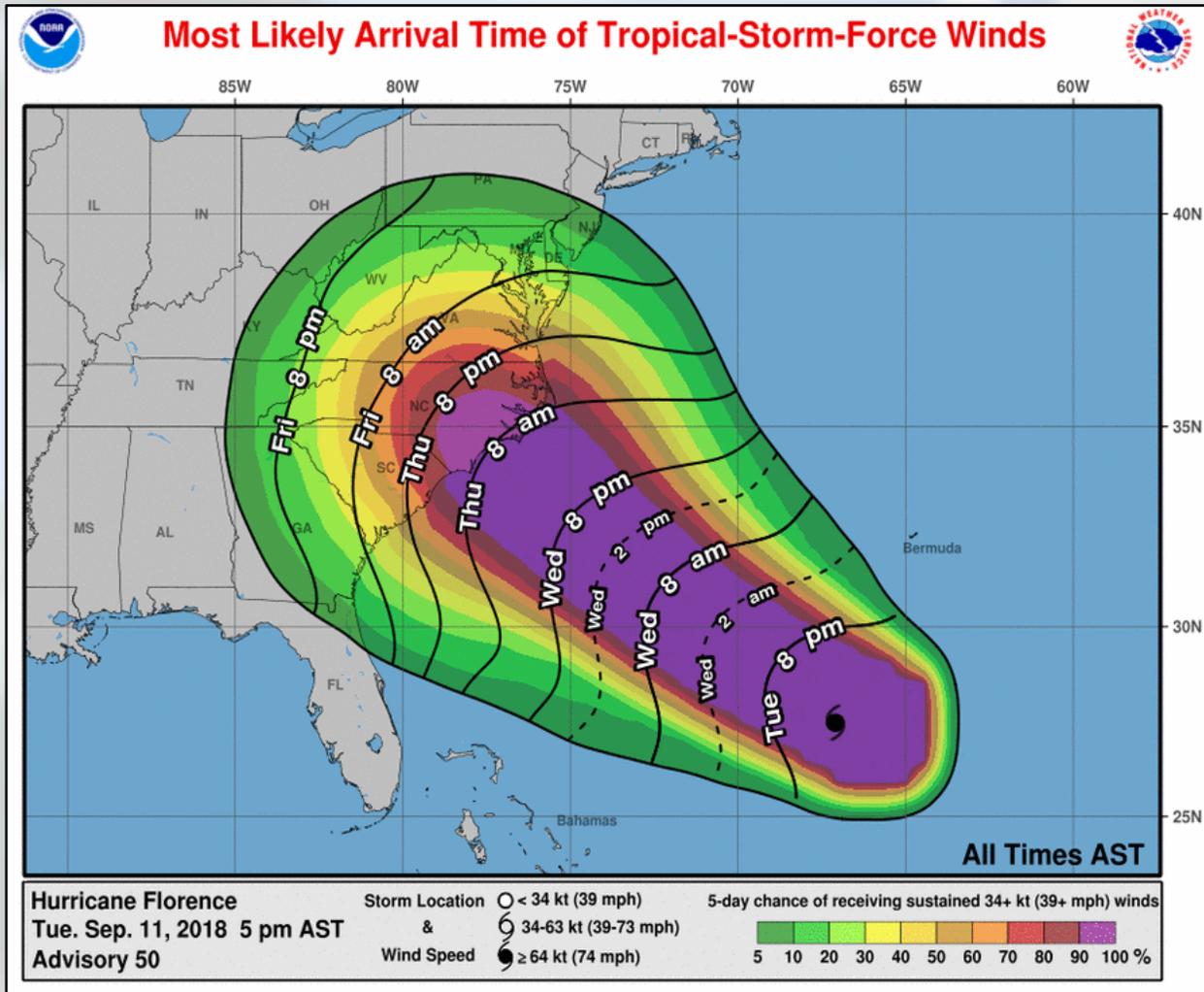


- What is the individual probability of each pin being hit by the bowling ball?
- What is the probability that the bowling ball hits any of the pins?



“I know too well that these arguments from probabilities are imposters, and unless great caution is observed in the use of them, they are apt to be deceptive.” – Plato (died 348 B.C.)

# Point Probabilities



“This branch of mathematics [Probability] is the only one, I believe, in which good writers frequently get results which are entirely erroneous” – Philosopher Charles S. Peirce (1839-1914)

# Low Probabilities at Long Lead Times



“Million-to-one odds happen eight times a day in New York” – Magician Penn Jillette (1955- )

# Why Is Risk Communication So Tricky?

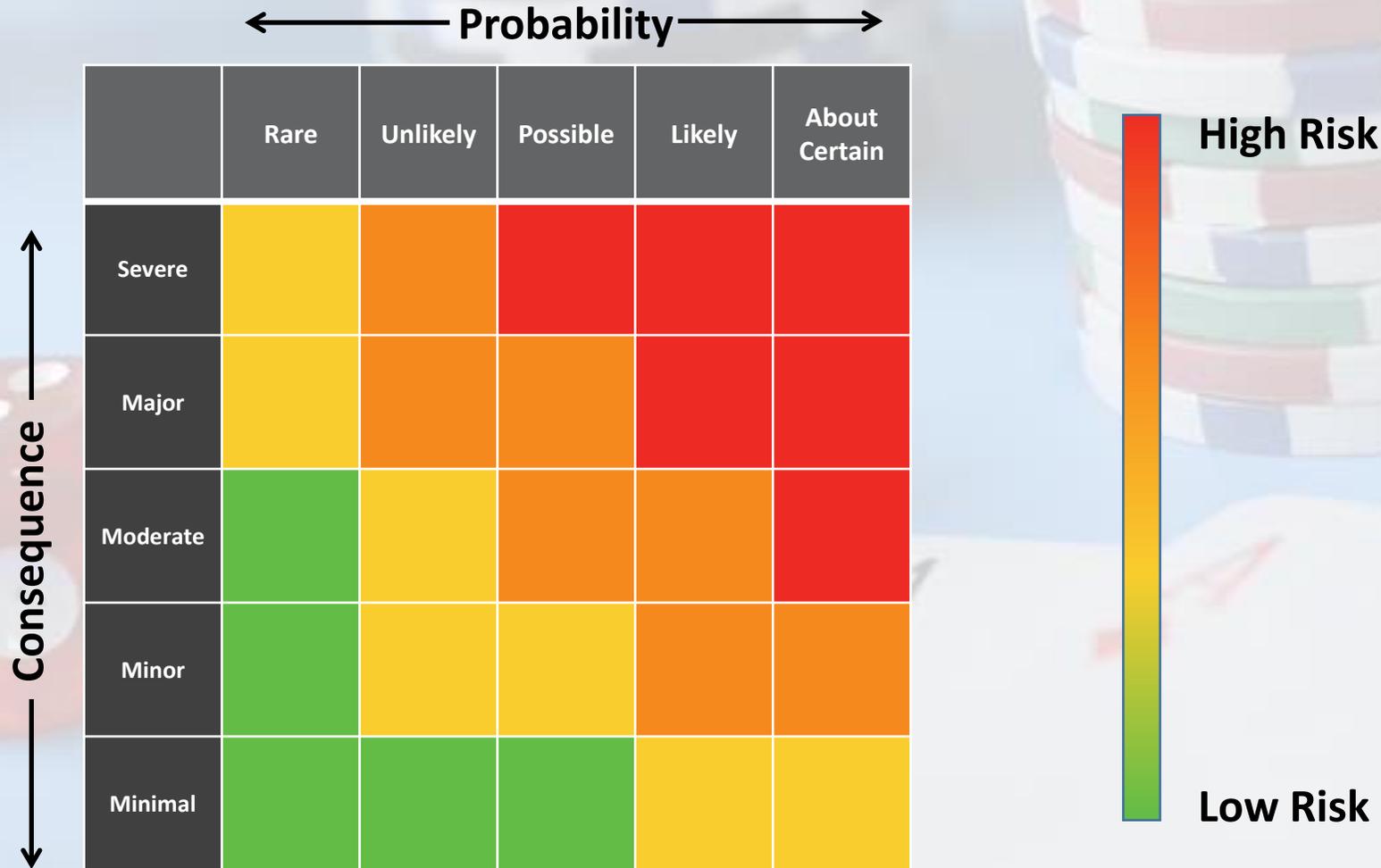
## Risk, Risk Perception, and Risk Tolerance

- Risk: the potential of gaining or losing something of value

$$\text{Risk} = \text{Probability} \times \text{Consequence} \times \text{Vulnerability}$$

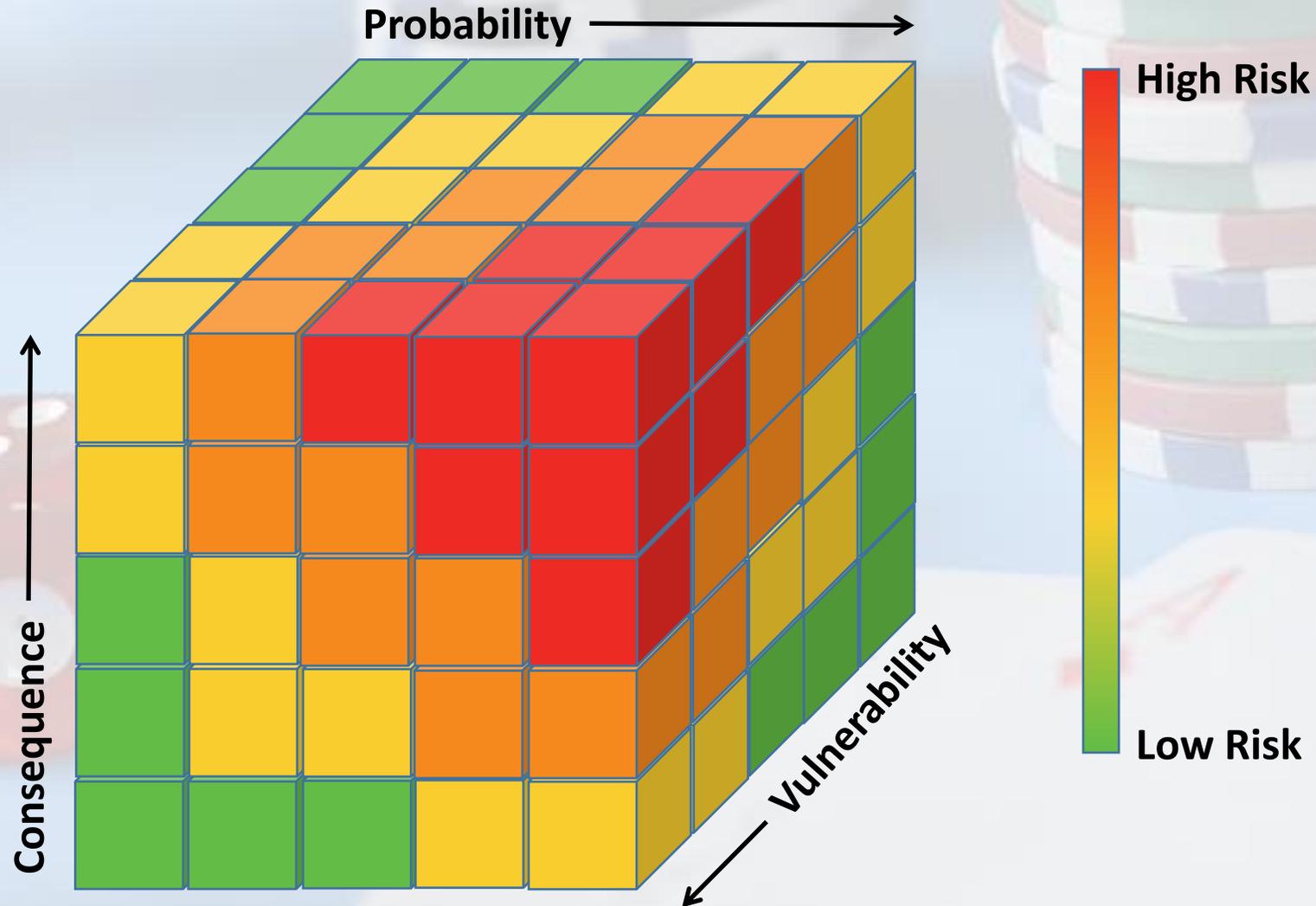
# Low-Probability, High-Consequence Events

(why low probabilities matter)



“The 50-50-90 rule: Anytime you have a 50-50 chance of getting something right, there’s a 90% probability you’ll get it wrong.” – TV writer Andy Rooney (1919-2011)

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# Why Is Risk Communication So Tricky?

## Risk, Risk Perception, and Risk Tolerance

- Risk: the potential of gaining or losing something of value

$$\text{Risk} = \text{Probability} \times \text{Consequence} \times \text{Vulnerability}$$

- Risk perception: the subjective judgment people make about probability, consequences, or vulnerability, which may vary from person to person

$$\text{Actual Risk} \neq \text{Perceived Risk}$$

- Risk tolerance: how willing people are to “take their chances”

# Risk Tolerance

***Which choice would you make?***

**A. Receive \$100 guaranteed**

**B. Flip a coin, “heads” you win \$200, “tails” you win nothing**

***Which choice would you make?***

**A. Flip a coin, “heads” you lose \$200, “tails” you lose nothing**

**B. Lose \$100 guaranteed**

# Risk Tolerance



People tend to be **risk-averse** when they see themselves as **gaining** something

Prefer to take the sure thing (receiving \$100), rather than gamble (receiving \$200 or nothing)



People tend to be **risk-seeking** when they see themselves as **losing** something

Prefer to gamble (losing \$200 or nothing), rather take the sure thing (losing \$100)

**The pain of losing a thing > the pleasure of winning that thing**

“Life is a school of probability.” – Journalist Walter Bagehot (1826-1877)

# Risk Tolerance: Spectrum of Plausible Outcomes

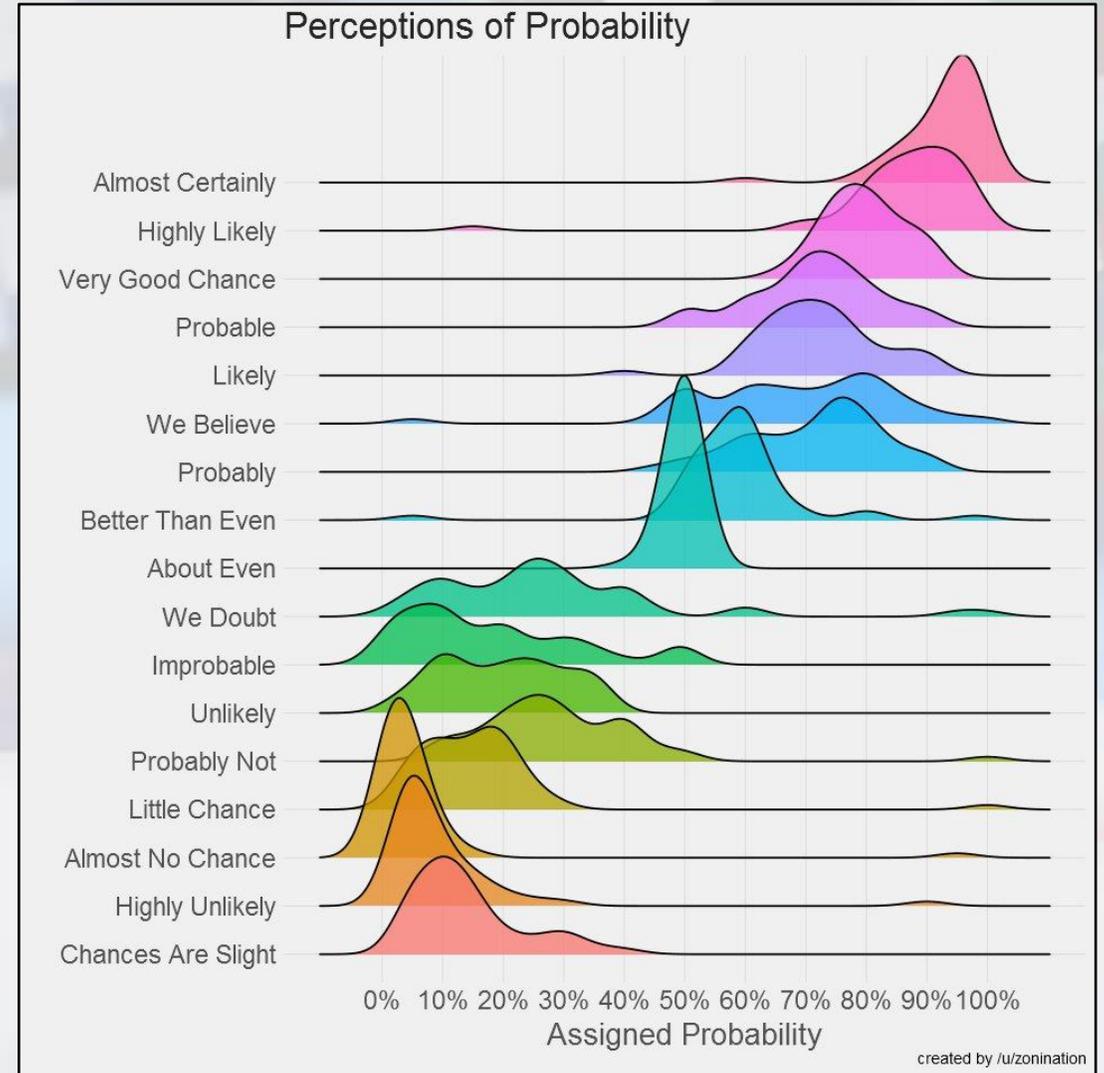
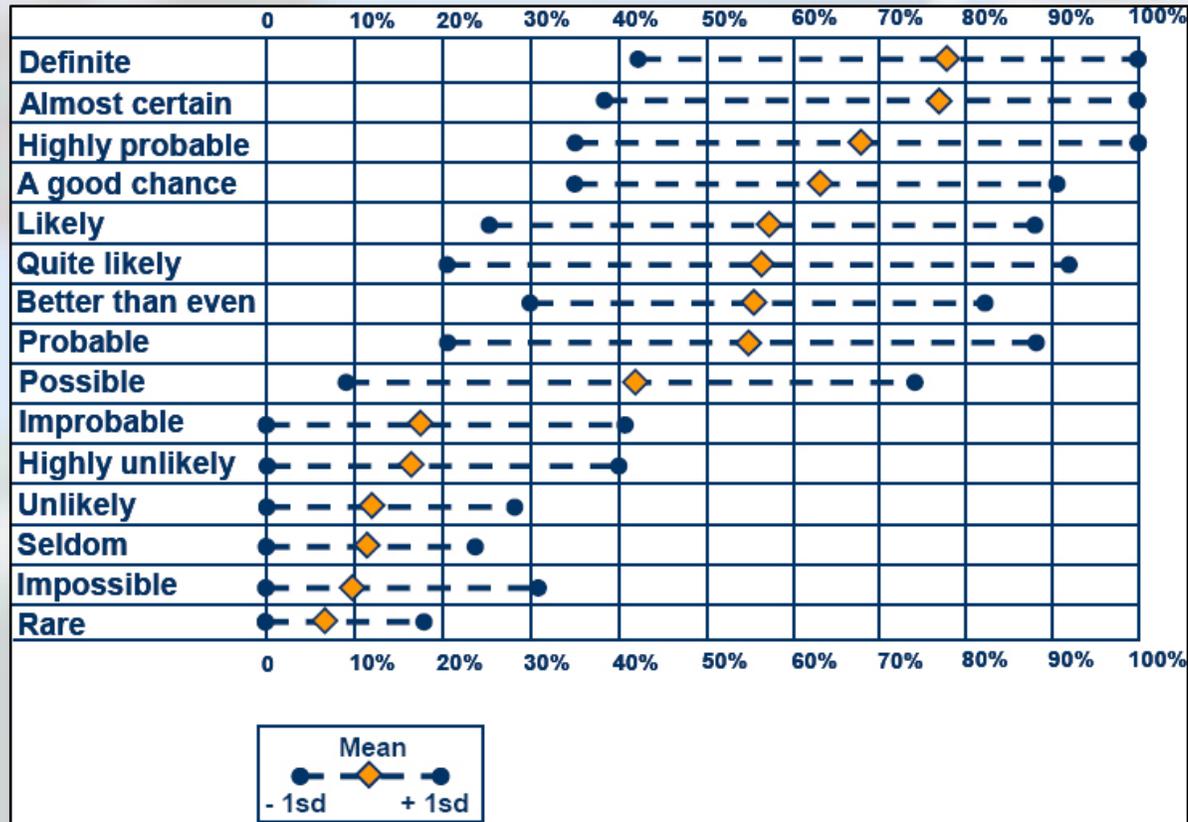
*(in event context; for a given community)*



"Fate laughs at probabilities." – Novelist Edward Bulwer-Lytton (1803-1873)

# A Word of Caution: Words of Estimative Probability (WEPs)

Hillson (2004)



“One must be careful with words. Words turn probabilities into facts and by sheer force of definition translate tendencies into habits” – Author Fay Weldon (1931- )



# Likely Takeaways

- **Be clear in stating the correct reference class for a probability**
  - Includes differentiating between point-specific and areal probabilities
- **Low probabilities can contribute to high risk**
  - Many users have a low risk tolerance, so low probabilities matter
- **It can be socially awkward (or even dangerous) for people to have different interpretations of words of estimative probability**