Economic Assessment of Risks in Maritime Navigation across the Greater Caribbean Region (GCR)

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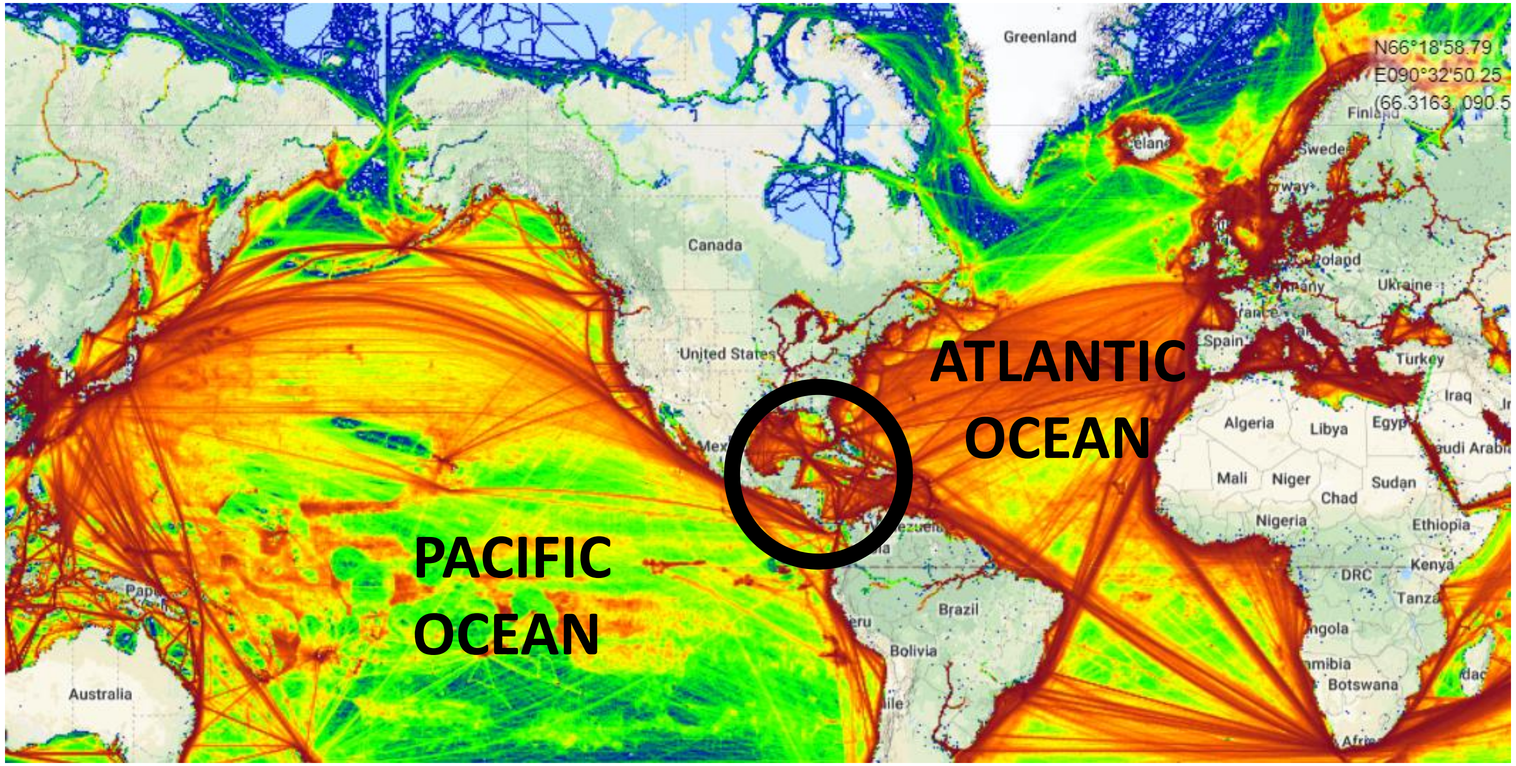


Introduction to this Study

- Maritime navigation is important to the Greater Caribbean Region (GCR) because it facilitates economic expansion.
- However, the environment, economy and culture of the region are at risk of unwanted events which can have short- or long-term consequences.
- This study therefore involves an economic assessment of risk in maritime navigation across the GCR.

The World's largest ship based oil spill took place within Trinidad & Tobago's EEZ, 1979.

Structure of the Presentation

1. Introduction
2. Significance
3. Strategies tested
4. Preliminary results
5. Method being formulated
6. Ongoing research

History of Maritime Accidents across the GCR

Ninety accidents were reported across the GCR over the last 17 years including:

- 9 Foundered
- 10 Collisions
- 14 Groundings
- 11 Capsize
- 13 Mechanical and Technical Failure

Source: Maharaj 2019

Significance of the Study

The results will contribute to the monitoring and management of maritime navigation by supporting the:

i. Prioritization of resources

ii. Reduction of risk

iii. Improved security of the marine environment

iv. Expansion of international trade opportunities

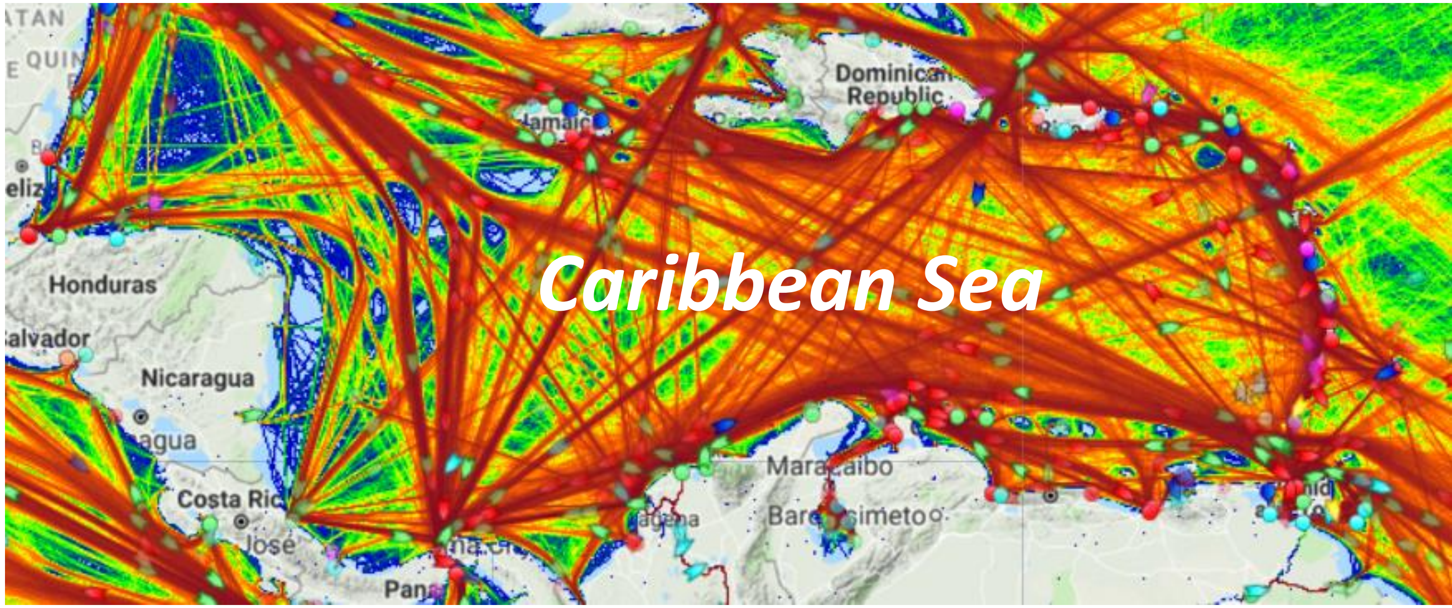
Aim and Objectives

Aim:

To conduct an economic assessment of risks in maritime navigation across the Greater Caribbean Region (GCR)

Objectives:

1. Formulate a risk assessment strategy
2. Generate an economic model to estimate losses associated with maritime accidents



Source: Marine Traffic

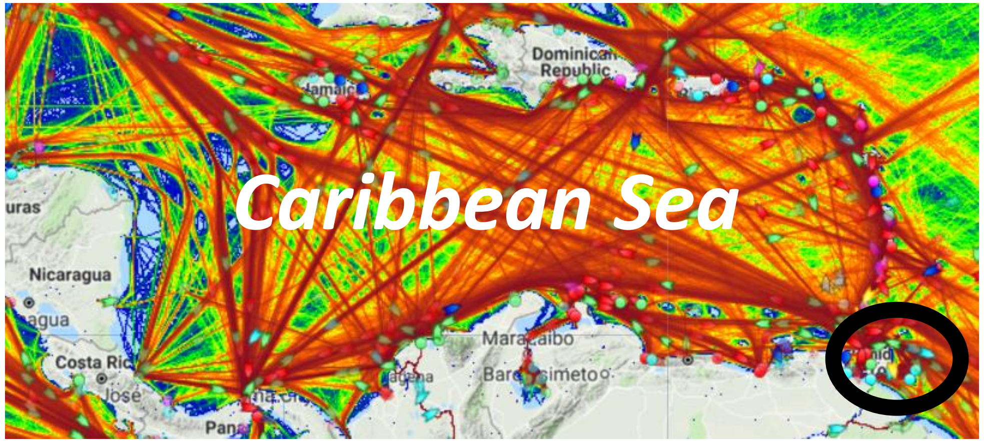
Commonly Used Strategies for Conducting Risk Assessments

Strategies for risk assessment were developed by maritime departments including:

1. **IALA Waterway Risk Assessment Programme (IWRAP)**
2. **Land Information New Zealand (LINZ)**
3. Canadian Hydrographic Service
4. Arctic Region Hydrographic Commission
5. National Oceanic and Atmospheric Administration

IALA considers traffic flow while the others used traffic density.

LINZ and IWRAP Strategies Applied to the Gulf of Paria



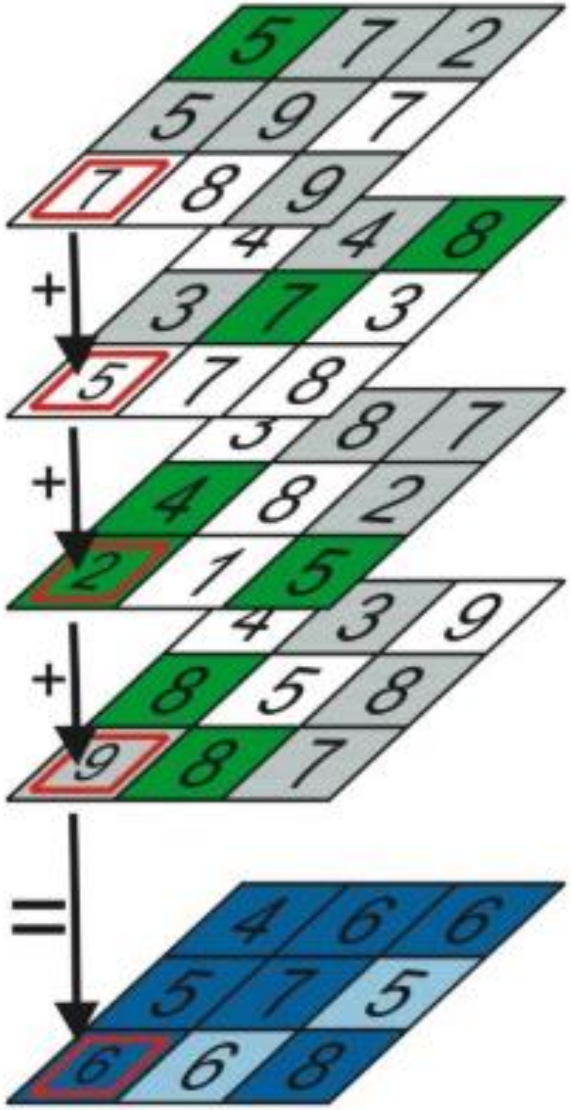
Source: Marine Traffic

General Outline of the Hydrographic Risk Assessment Strategy developed by Land Information New Zealand (LINZ)

1. Applies **data** from satellite & terrestrial automatic identification systems.

2. Applies a **weighted modelling** approach – The scores are acquired from expert judgement.

3. Represents the relative level of risk on a **heatmap**.

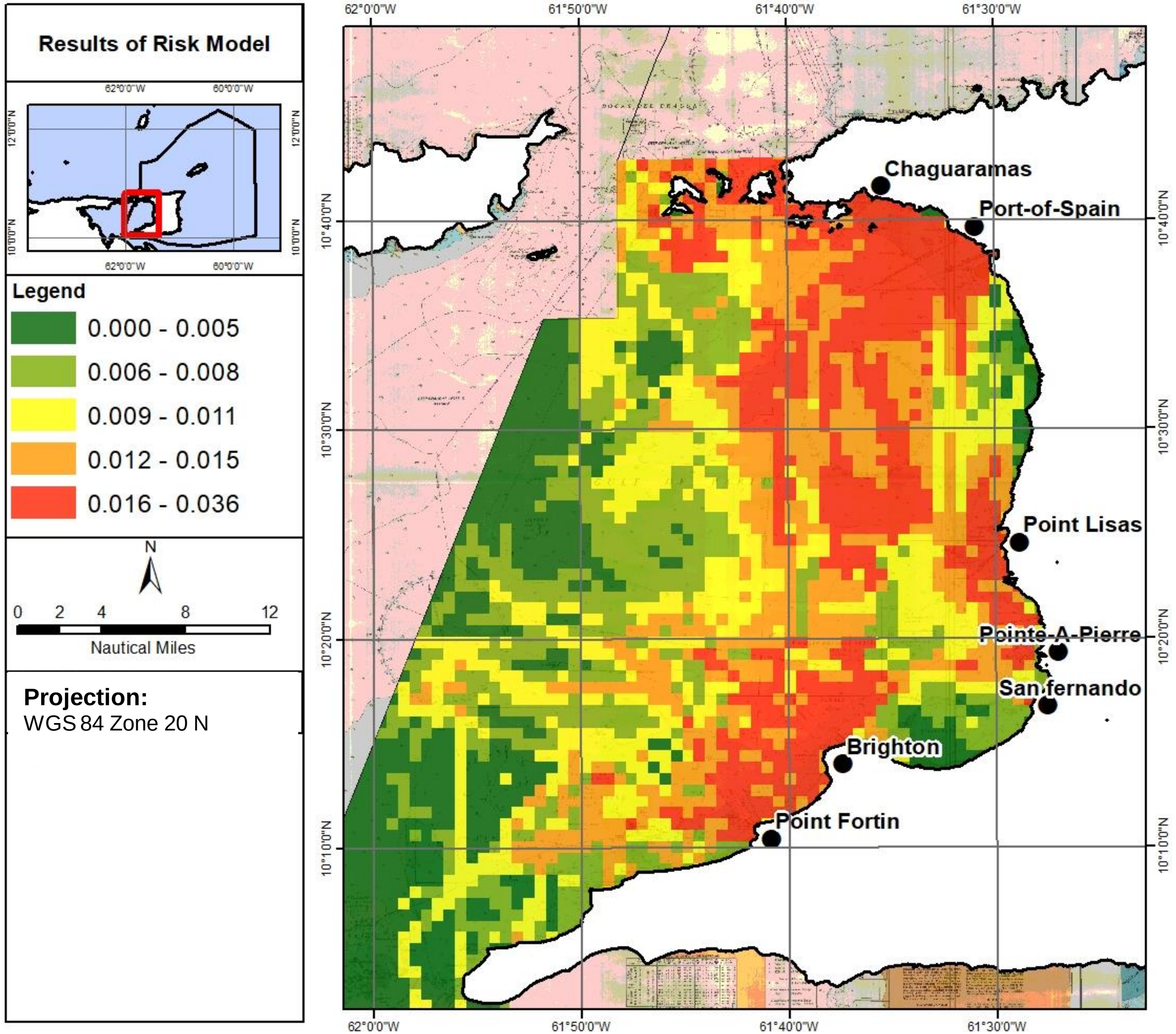


Results of the Hydrographic Risk Assessment developed by Land Information New Zealand

There is risk in maritime navigation across the GOP.

Levels of Risk in Maritime Navigation	
	Catastrophic
	High
	Moderate
	Low
	Insignificant

Under the LINZ strategy, no units are associated with the risk value.



General Outline of the Strategy Developed by the IALA Waterway Risk Assessment Programme (IWRAP)

IWRAP calculates the probability of grounding, allision or collision based on:

1. The average number of potential accidents (near misses), assuming that no evasive action is taken (blind navigation).

2. Then adjusts this number by multiplying it with the **probability that an evasive action fails.**

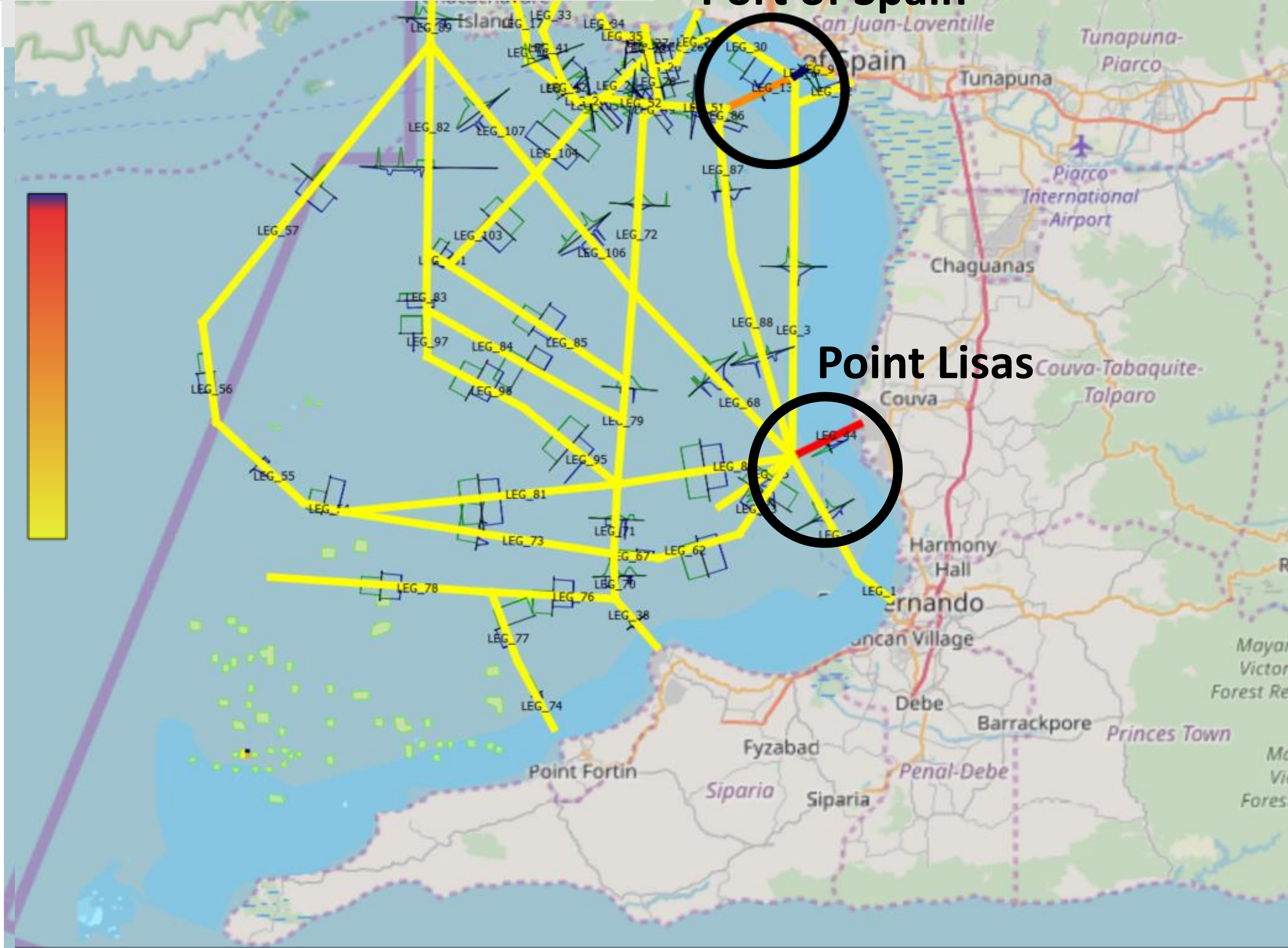
Probability an evasive action fails

Condition	Causation Factor
Head on collision	$0.5 X 10^{-4}$
Overtaking collision	$1.1 x 10^{-4}$
Crossing collision	$1.3 X 10^{-4}$
Collisions in bend	$1.3 X 10^{-4}$
Collisions in merging	$1.3 X 10^{-4}$
Grounding – forgot to turn	$1.6 X 10^{-4}$

Results of the Strategy Developed by the IALA Waterway Risk Assessment Programme (IWRAP)

- The approach channels to Port of Spain and Point Lisas are at risk in maritime navigation
- There is pilotage in these areas

Collisions are expected to occur every 149 years



Notes about applying IWRAP Risk Model to GOP

Likelihood of accidents:

- Does not use satellite AIS data

Consequences of accidents:

- Does not model consequences of accidents

Risk Value:

- Does not include a measure of consequences

  Limits on how much data can be processed but it can be managed

Notes about applying LINZ Risk Model to GOP

Likelihood of accidents:

- Based on subjective weights

Consequences of accidents:

- Does not measure consequences as an **economic loss per year**

Risk Value:

- Provides a relative risk value with no units

This method is also time consuming.

Development of Strategy – Economic Assessment of Risks in Maritime Navigation across the GCR

- Applies historical satellite AIS data and statistical techniques to simulate vessel traffic events across main shipping routes.

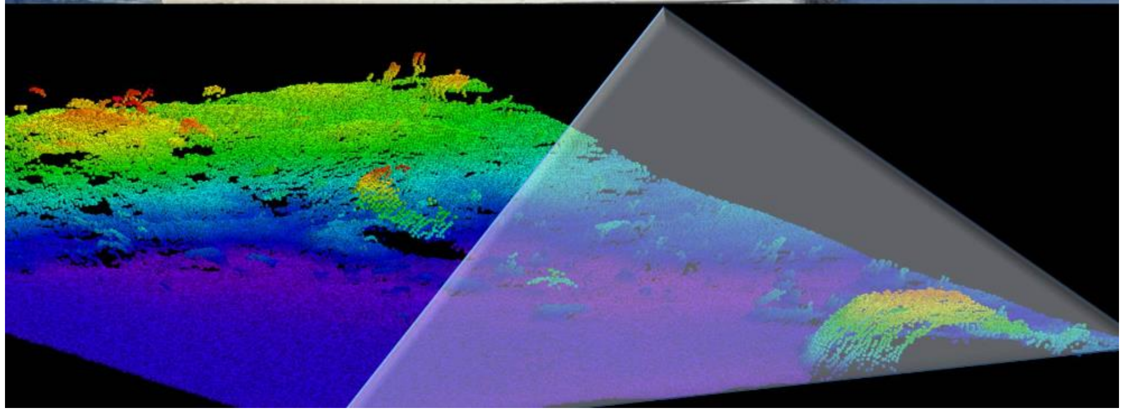
- Within territorial waters, the strategy calculates the following per sq km, per year:
  1. Probability of collisions and groundings
  2. Consequences of incident in terms of economic losses ($)

  Final risk value = probability score x consequence score

Development of Strategy – Economic Assessment of Risks in Maritime Navigation across the GCR

- The final risk value indicates the level of risk due to collisions or groundings, in relation to the potential cost of the incident.

- This value is well suited to recommend risk control options, for example the prioritization of resources to conduct hydrographic surveys.



Main Features of the Strategy being Developed –
Statistical Analysis of Vessel Position Information along Shipping Routes

- Errors in satellite AIS data are corrected using public databases.

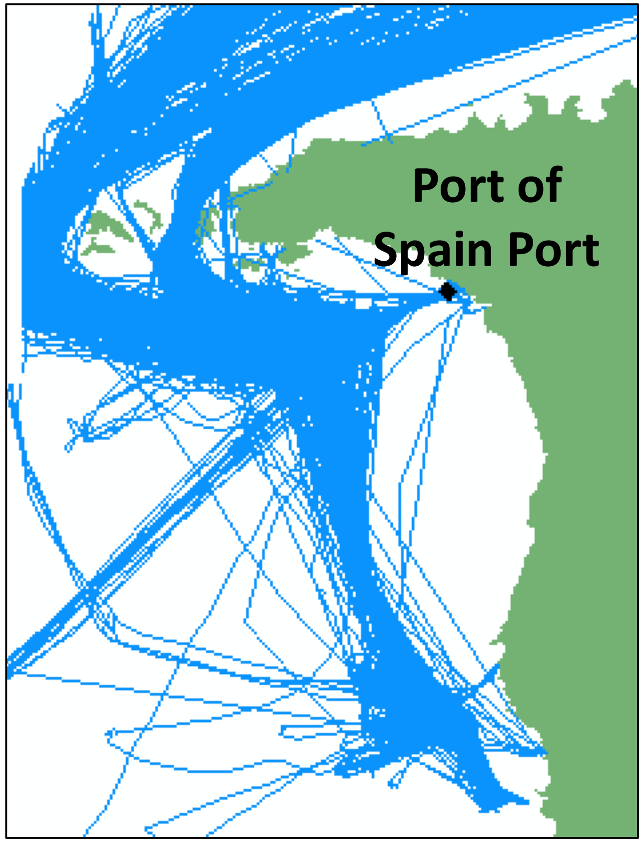
KASTELLI WAVE	209723000	2011
UBC MONTEGO BAY	209747000	0
UBC MONTEGO BAY	209747000	0
UBC MONTEGO BAY	209747000	0
UBC MONTEGO BAY	209747000	0
ORCHID	209759000	0
VENUS HORIZON	209786000	2012
WARNOW WHALE	209862000	2007
WARNOW WHALE	209862000	2007

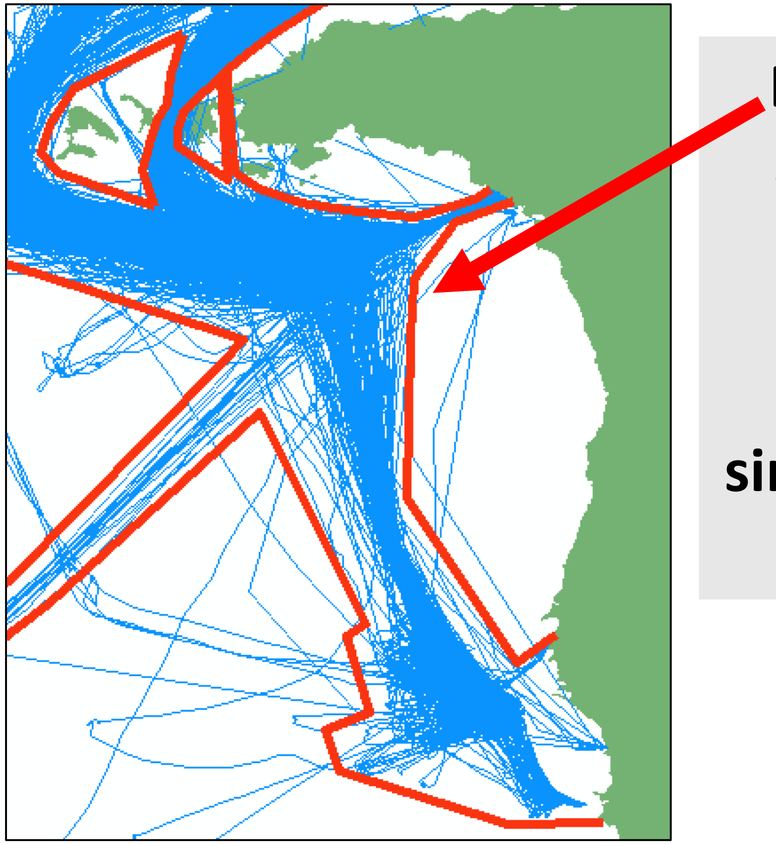
The year this ship was built was not provided in the AIS dataset

Main Features of the Strategy being Developed – Statistical Analysis of Vessel Position Information along Shipping Routes

Boundaries of the main shipping routes to/from each port are created

Transit of 1,000 vessels which visited the Port of Spain Port





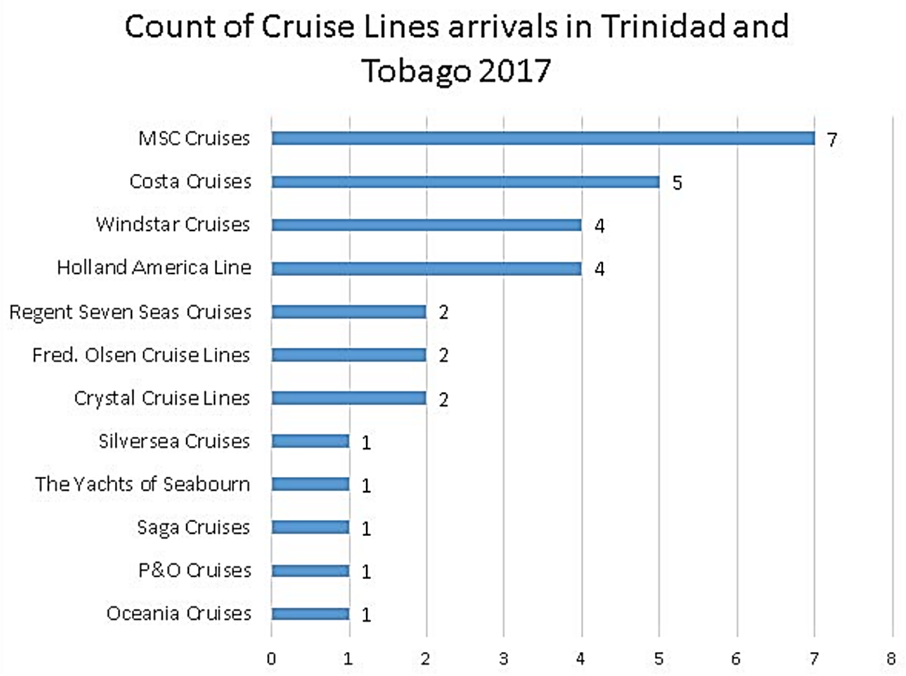
Boundaries of main shipping routes are created.

Vessel transits are simulated within these boundaries

Main Features of the Strategy being Developed – Statistical Analysis of Vessel Position Information along Shipping Routes

The following are statistically analyzed for each port:

1. Locations of vessel arrivals and departures
2. Frequency of vessel arrivals and departures
3. Ships' attributes along each identified route



Main Features of the Strategy being Developed – Space – Time Simulation of Vessel Transits and Ship Domains

Space-time simulation of various scenarios of vessel transits with ship domains, are performed along each route.

```
#------------------------------------CREATE TIMESTAMPS------------------------------------------

#Randomly generate the number of timestamps based on the number of points generated from the lines

N = numberTrafficEvents # Number of randomly selected traffic events
T = 24.0    # Epoch
lmbda = N/T/60/60 # Frequency of transit per second
lmbda
x = np.arange (count)
y = -np.log(1.0 - np.random.random_sample(len(x))) / lmbda #randomly generate timestamps
x_out = x + 1
outputArray = np.column_stack([x_out,y])
np.savetxt("outputArray5.csv", outputArray, delimiter=",") # export as a .csv file in the visual studio folder.

#np.set_printoptions(threshold=np.nan) #print timestamps in the terminal, without ellipses
#y[:1083511] #number of timestamps - this will print the timestamps in visual studio termminal window with ellips
```

Main Features of the Strategy being Developed – Example of Space –Time Simulation of Vessel Transits and 2D Ship Domains

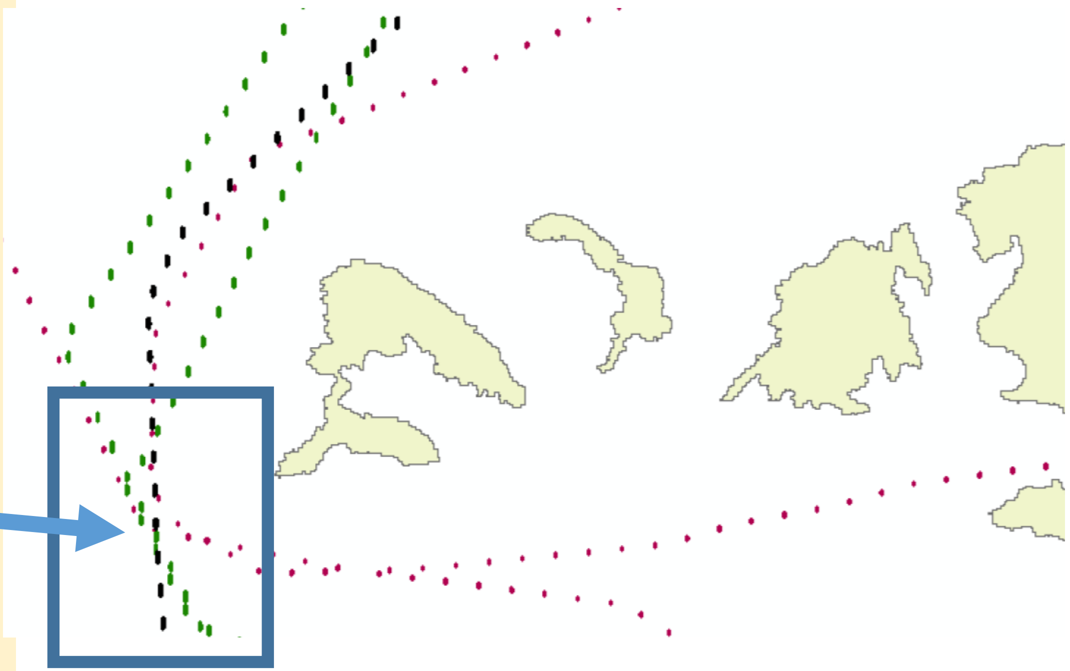
Simulation of 3 vessels leaving Port of Spain:

i. Waypoints
ii. Vessel heading
iii. Departure times
iv. Attributes of vessels
v. ship domains - based on the dimension of the vessels

Collision candidates can be observed in the Bocas area.

Note: 'Filters' to include bathymetry and type of seabed are not included in this example.

Collision candidates are indicated by vessels transiting within 0.5 – 1 nm of each other



Main Features of the Strategy being Developed – Calculate the Likelihood of Collision and Groundings Per Unit of Area

- The number of collision and grounding candidates per sq km are multiplied by a causation factor, based on the type of vessels.

- The quantile data distribution method is applied across the study area, to distribute the results across a five point scale and assign a score of from 1 - 5.

Catastrophic	Very high	High	Low	Very low	No Data
5	4	3	2	1	0

Main Features of the Strategy being Developed – Valuation of Sensitive Marine and Coastal Areas

- Market and non-market valuation techniques are used to estimate the value of marine and coastal areas, in terms of potential economic losses per year.

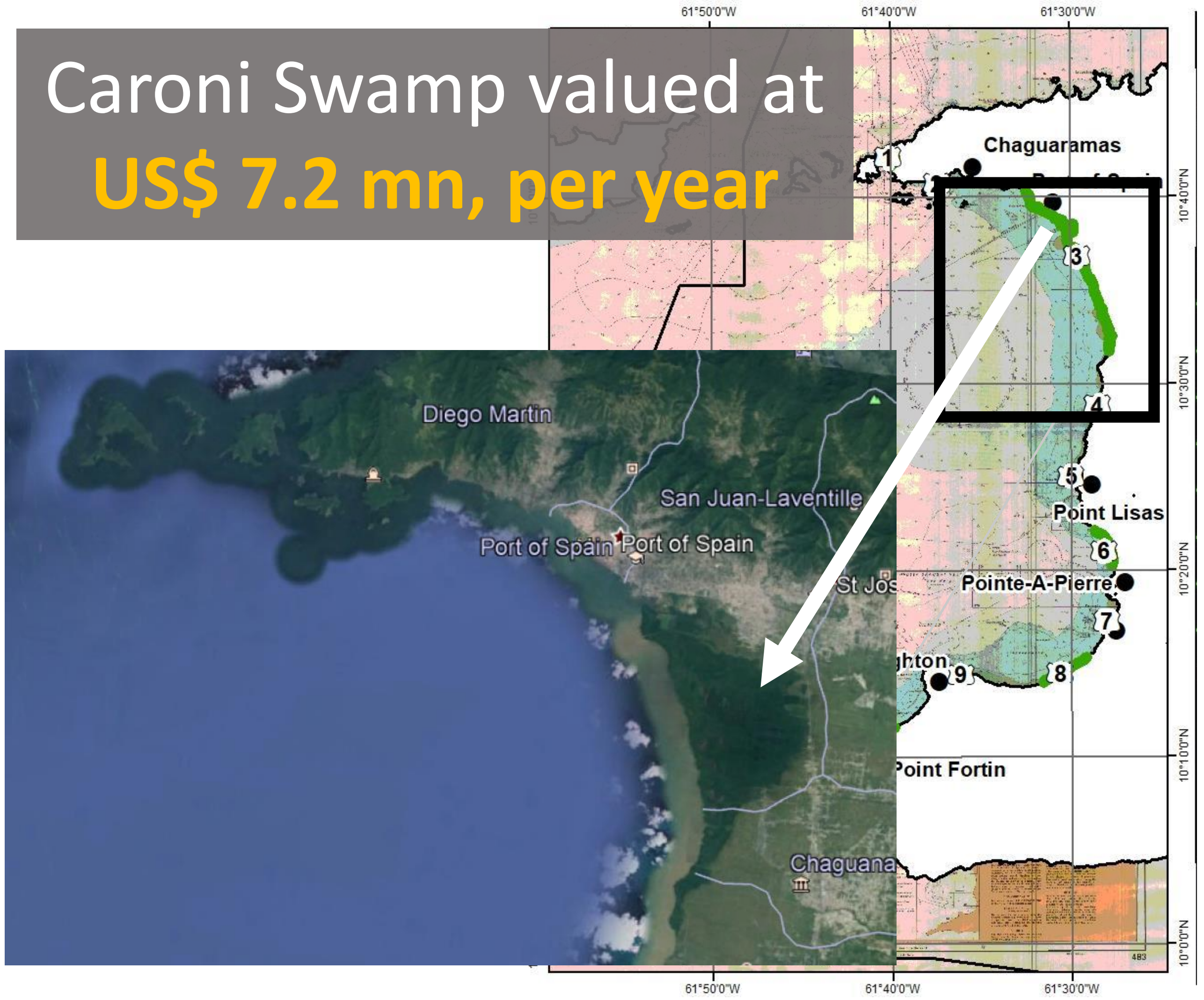
- The quantile data distribution method is applied across the study area, to distribute the results across a five point scale and assign a score of from 1 - 5.

Catastrophic	Very high	High	Low	Very low	No Data
5	4	3	2	1	0

Example: Non-Market Valuation Method applied to Calculate the Benefit of Protecting Swamps

- 1,200 USD/hectare/year x 6,000 hectares
- The Caroni Swamp is valued at 7.2 mn USD/year.
- If 10 % of the Caroni Swamp is damaged: 0.72mn USD

Caroni Swamp valued at
US$ 7.2 mn, per year



Calculation of the Final Risk Value to Inform Risk Control Options

RISK VALUE MATRIX		LIKELIHOOD				
		Very Rare (1)	Rare (2)	Occasional (3)	Frequent (4)	Very frequent (5)
CONSEQUENCE	Catastrophic (5)	5	10	15	20	25
	Major (4)	4	8	12	16	20
	Severe (3)	3	6	9	12	15
	Minor (2)	2	4	6	8	10
	Insignificant (1)	1	2	3	4	5

Reduce to As Low As Reasonably Practicable (ALARP) level using Risk Control Options.

ALARP

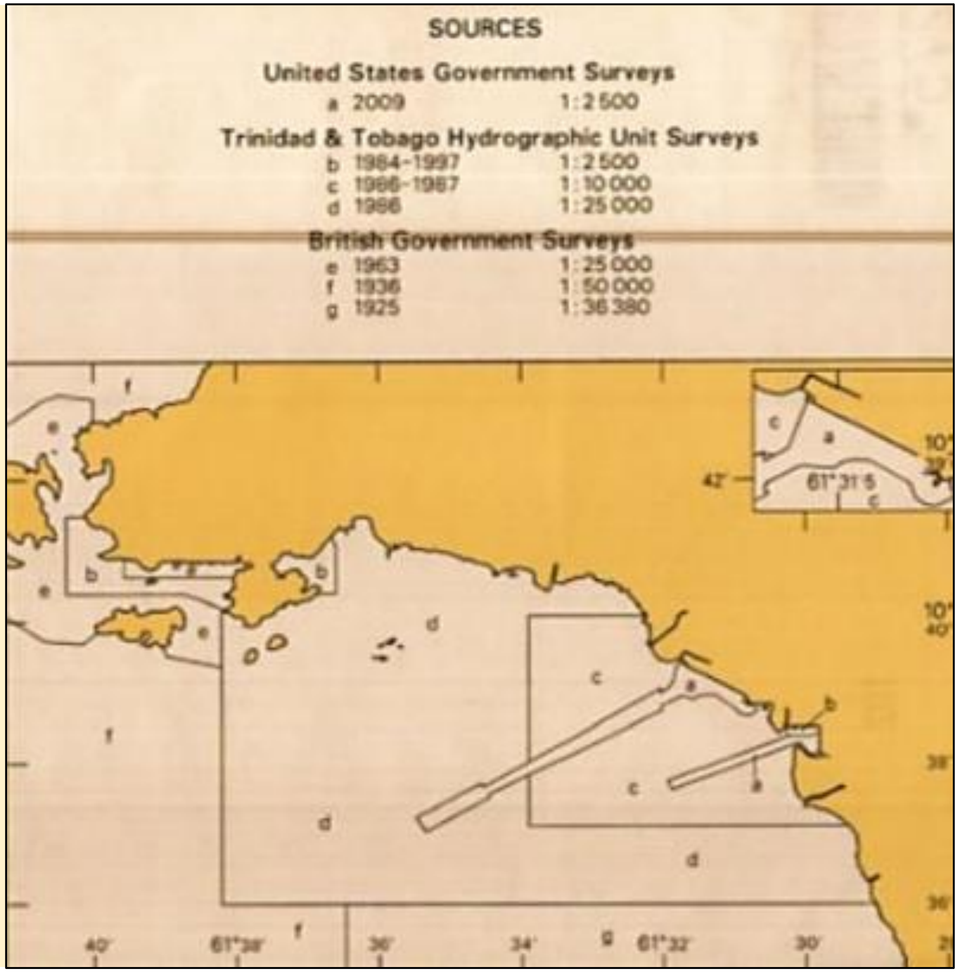
Adapted from IALA

Main Outputs from the Strategy being Developed – Economic Assessment of Risks in Maritime Navigation

The strategy can provide:

- Detailed information about the circumstances of collision and grounding candidates and the value of marine and coastal areas where collision candidates are identified

- A risk value per sq km, which is well suited to make decisions about risk control options



Ongoing Objectives

Presently, an average of ten vessel transit the Gulf of Paria / day.

The immediate objectives are to:

1. Refine filters to simulate an increase in vessel transits per day

2. Refine filters to accurately reflect the transit of vessels across the present operating environment

3. Calculate the final risk value and validate the results based on stakeholder consultation.

4. Extend the strategy to territories across the Greater Caribbean Region.

Conclusion

- A universal strategy for hydrographic risk assessment is unavailable at this time because each marine operating environment is different.

- Economic Assessment of Risks in Maritime Navigation provides a risk assessment strategy which is suitable for the operating environments in developing states:
  1. Uses satellite AIS data (T-AIS is unavailable in many developing areas).
  2. Simulates the most likely ship traffic as well as other possible scenarios
  3. Calculates the risk value per sq km which can be used to inform risk control options.

Data Required from Nautical Charts in a GIS Format across the Greater Caribbean Region

1. Age & Quality of nautical charts
2. Bathymetry
3. Coastline
4. Maritime boundaries
5. Ports
6. Aids to navigation
7. Protected areas
8. Tide and current
9. Fisheries
10. Offshore and coastal installations
11. Designated areas (for example spoil grounds & oil wells)
12. Underwater cables
13. Recreational areas
14. T-AIS data
15. Vessel accident information
16. Valuation reports for sensitive areas

Data Required from Nautical Charts in a GIS Format across the Greater Caribbean Region

1. Age & Quality of nautical charts
2. Bathymetry
3. Coastline
4. Maritime boundaries
5. Obstructions on the seafloor
6. Ports
7. Aids to navigation
8. Protected areas
9. Tide and current
10. Fisheries
11. Offshore and coastal installations
12. Designated areas (for example spoil grounds & oil wells)
13. Underwater cables
14. Recreational areas
15. T-AIS data
16. Valuation reports for sensitive areas
17. Marine casualties and accidents