Evaluación del riesgo

Clase

Riesgo

- Riesgo = f_a x Ne x C
  - f_a = número de accidentes por millón de encuentros
  - Ne = número de encuentros
  - C = alguna medida de la consecuencia del accidente

Steps

- Definición de riesgo
- Percepción del riesgo
- Estimación
- Mitigación

Risk

- Evaluación en función del número de accidentes ocurridos
- Pronóstico del número de accidentes a ocurrir
- Cálculo del número de encuentros que se producen en la vía navegable (mediante modelos)
- Fa = probabilidad de que ocurra un accidente en “accidentes cada 1000 pasajes” o “accidentes cada 1000 encuentros”
- Datos de otros puertos

Mitigación del riesgo

- Métodos de mitigación
  - VTS
  - Límites de operación
    - Reglas de operación
  - Ayudas a la Navegación
  - Practicaje
  - Esquemas de separación de tráfico

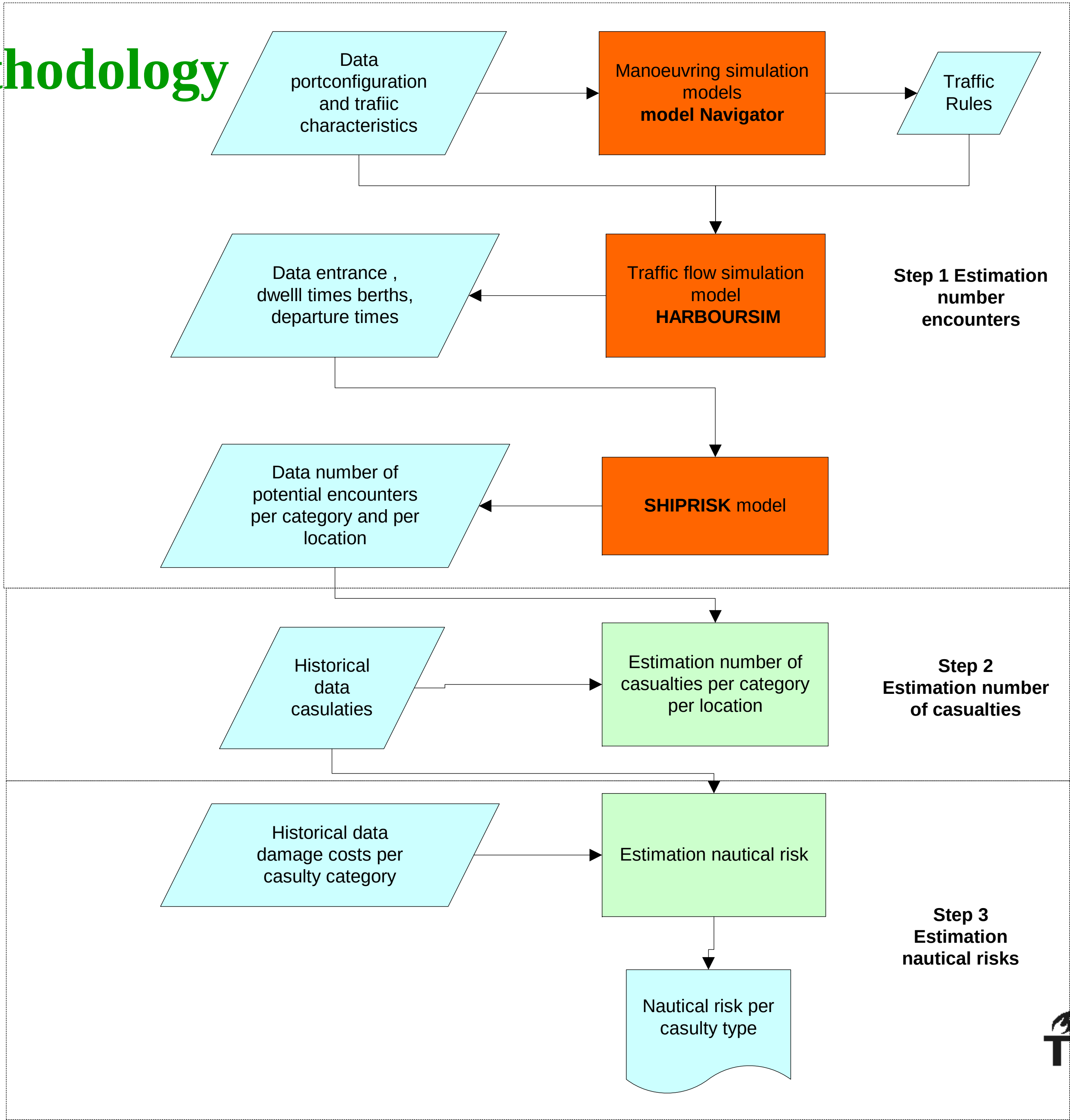
Comparación de costos

- Si implemento una medida de mitigación tengo
  - El costo de implementar esa medida
    - Fácil de evaluar
  - El beneficio de disminuir el riesgo de navegar por ese canal (disminuyo número de accidentes)
    - Difícil de evaluar
    - Costos políticos

Modelos

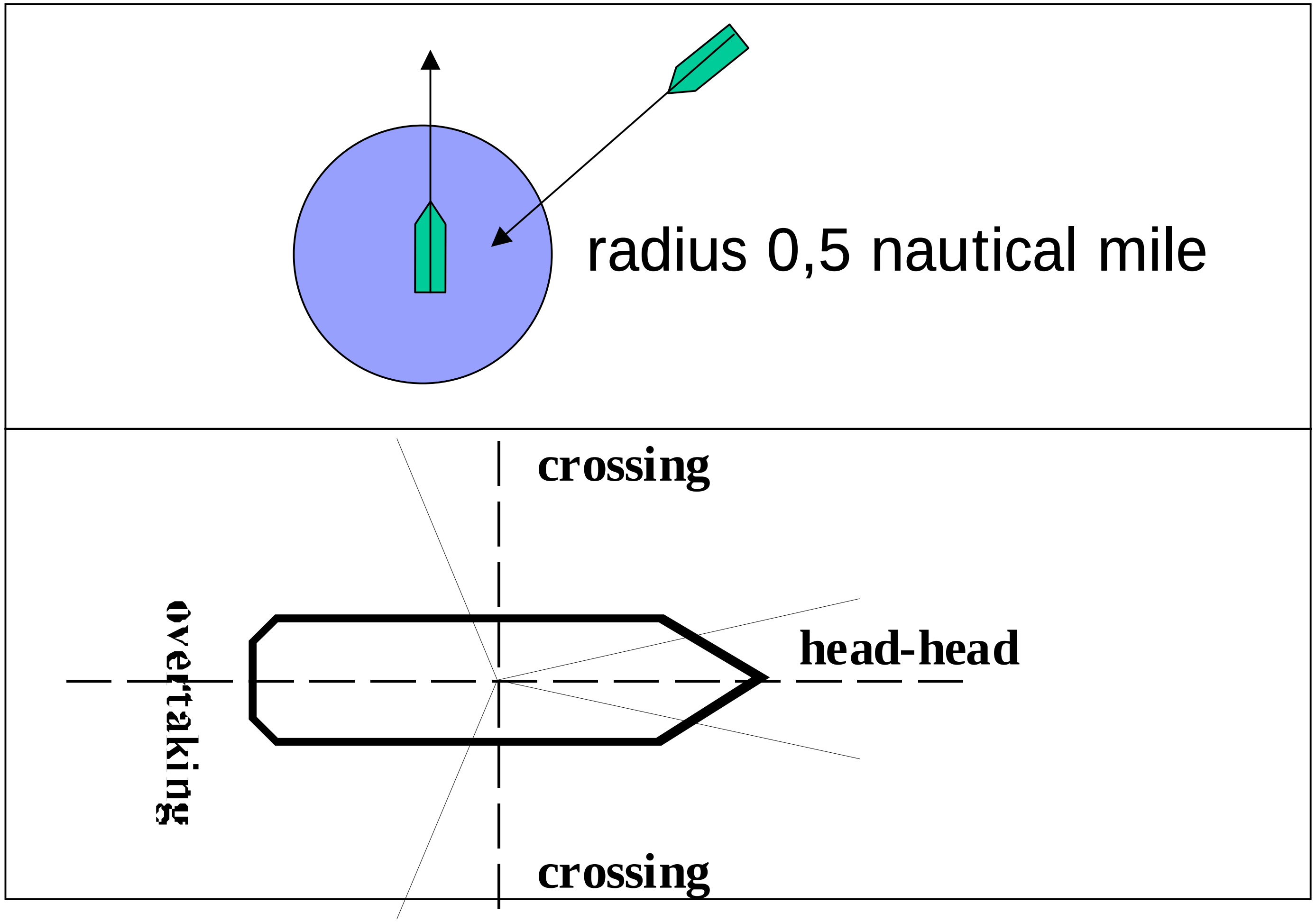
- Cualitativo
- PAWSA – Ports and Waterways Safety Assesment
  - http://www.navcen.uscg.gov/mwv/projects/pawsa/PAWSA
- Cuantitativo
  - ShipRisk – TU Delft
  - SMART - MARIN
- IALA IWRAP

Methodology



TU Delft

ENCOUNTER DEFINITION



Number accidents per 10^6 encounters (registered in the Straight of Dover)

Visibility	Type encounter	Accidents
Good	head-head	6.2
	crossing	4.9
	overtake	6.2
Foggy visibility <1500m	head-head	88
	crossing	14
	overtake	90
Heavy Fog visibility <500m	head - head	290
	crossing	630
	overtake	350

TU Delft

Model Shiprisk

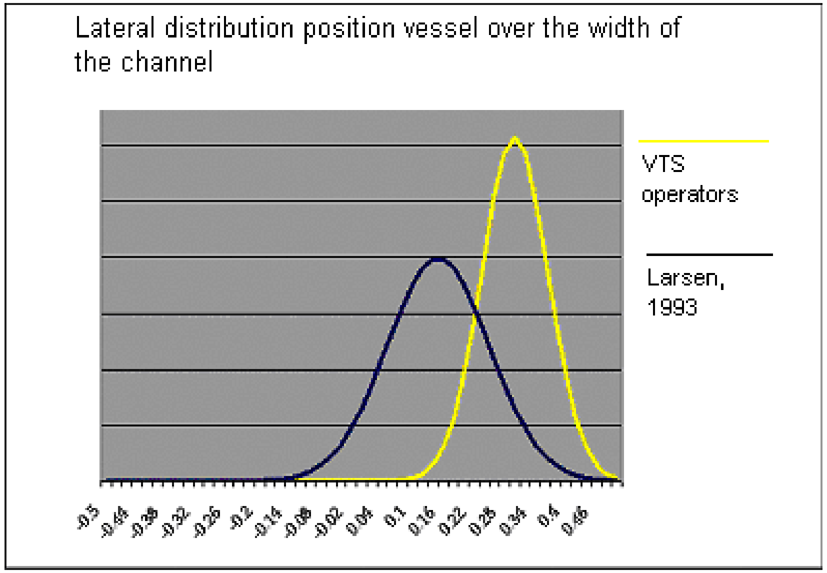
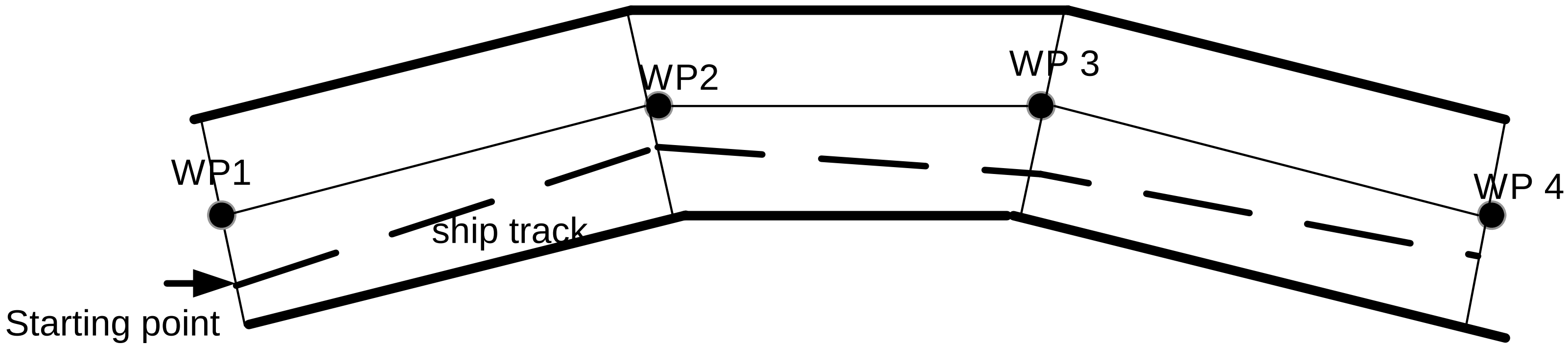
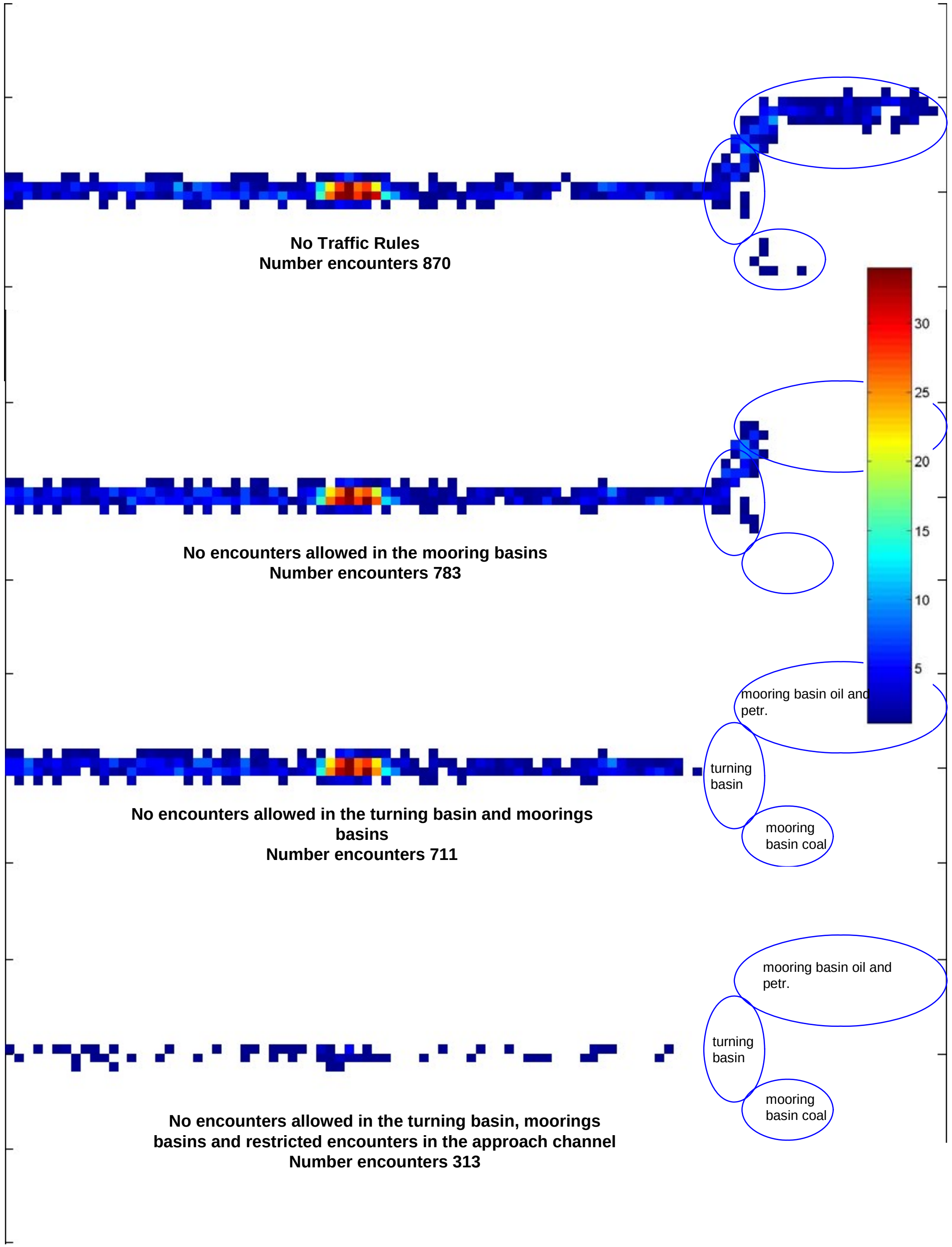


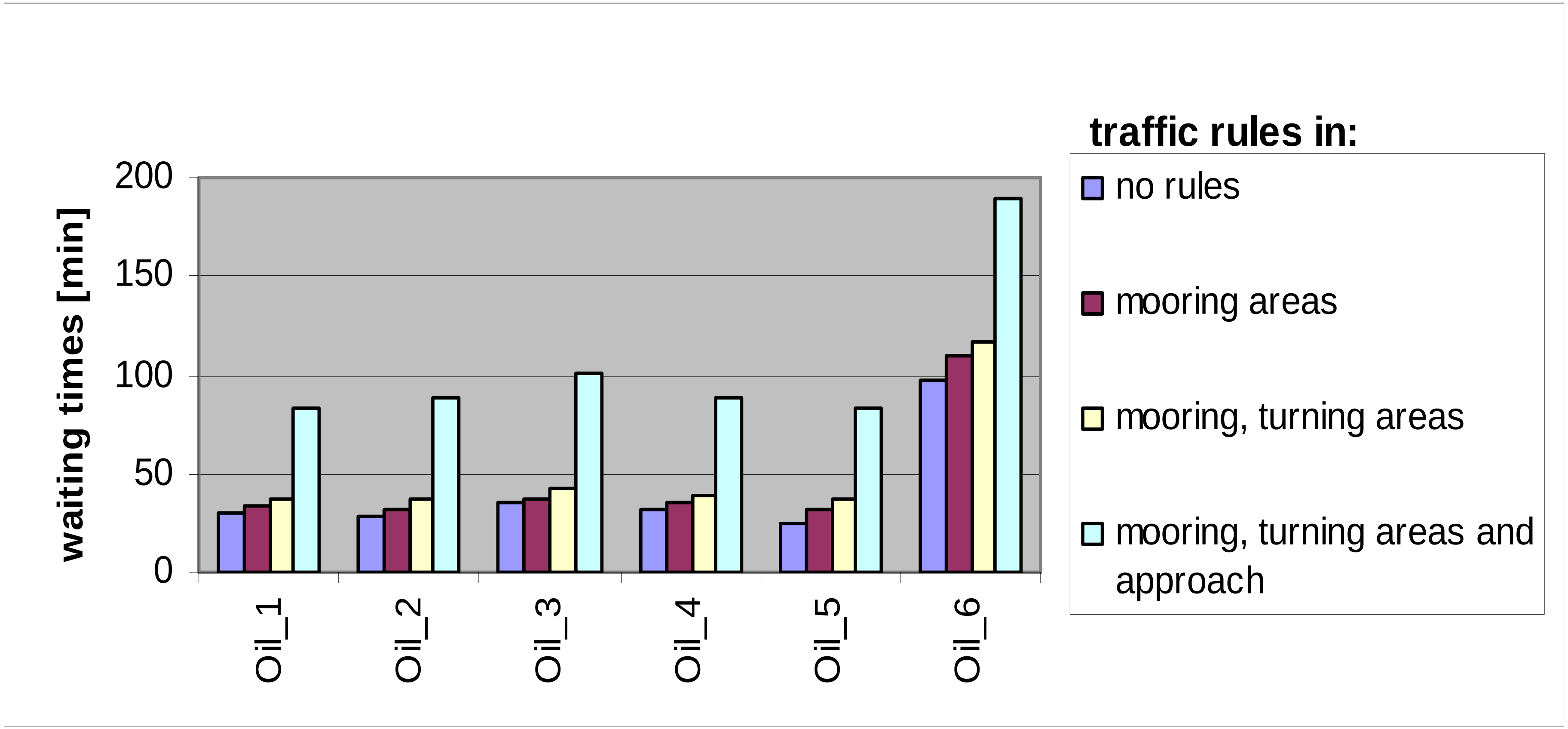
Figure 1 Lateral distribution ship position in the channel



Encounter densities, Puerto America



Waiting times versus traffic rules



PAWSA

- Risk can be defined as a measure of the probability of an unwanted event and its impacts or consequences (Lowrance 1978). The attributes that make up risk are, therefore, those that affect the accident probability and those that affect the impacts or consequences of potential accidents. Figure 1 shows the PAWSA model as a tree-like hierarchy, with the leaves showing the attributes determined by the National Dialog Group. In the hierarchy, the attributes are combined into six main groups. Four of these groups affect accident frequency, while the other two affect the consequences of potential accidents, each of which must be minimized to achieve the overall objective of maximizing safety in a given port or waterway.

Waterway Risk Model

- Since risk is defined as the product of the probability of a casualty and its consequences, the Waterway Risk Model includes variables dealing with both the causes of waterway casualties and their effects. The six risk categories determined were:

1. Vessel Conditions - the quality of vessels and their crews that operate on a waterway.
2. Traffic Conditions - the number of vessels that use a waterway and their interactions.
3. Navigational Conditions - the environmental conditions that vessels must deal with in a waterway relating to wind, currents, and weather.
4. Waterway Conditions - the physical properties of the waterway that affect how easy it is to maneuver a vessel.
5. Immediate Consequences - the immediate impacts of a waterway casualty: people can be injured or killed, petroleum and hazardous materials can be spilled and require response resources, and the marine transportation system can be disrupted.
6. Subsequent Consequences - the subsequent effects of waterway casualties that are felt hours, days, months, and even years afterwards, such as shoreside facility shut-downs, loss of employment, destruction of fishing areas, decrease or extinction of species, degradation of subsistence living uses, and contamination of drinking or cooling water supplies

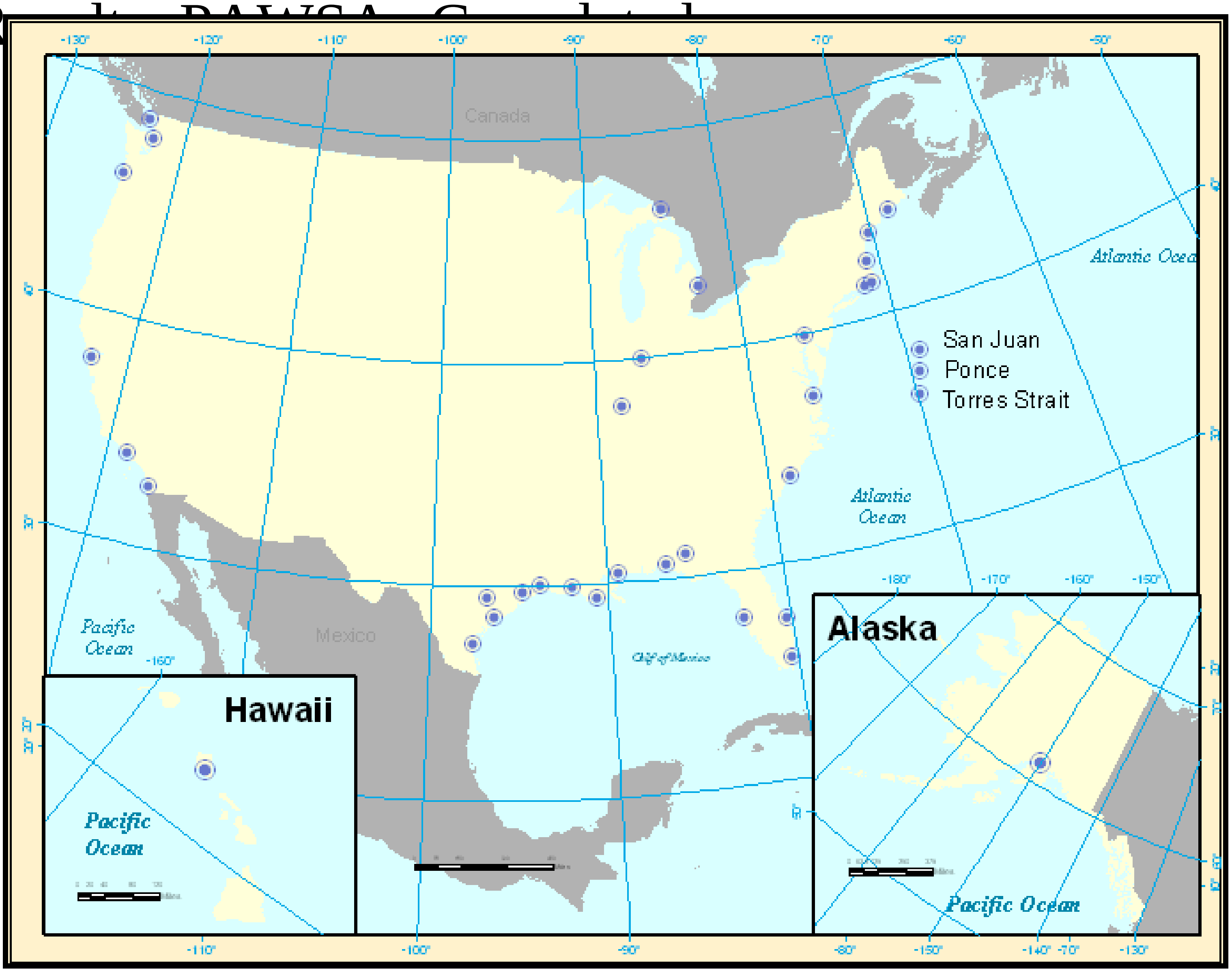
Waterway Risk Model

Vessel Conditions	Traffic Conditions	Navigational Conditions	Waterway Conditions	Immediate Consequences	Subsequent Consequences
Deep Draft Vessel Quality	Volume of Commercial Traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
Commerical Fishing Vessel Quality	Traffic Mix	Visibility Restrictions	Bottom Type	Hazardous Materials Release	Aquatic Resources
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic

Results

- 35+ conducted to date
- Final Report for first 28 waterways
- Various managers relying on results to effect change
  - Increased budgets
  - Improved infrastructure
  - New VTS's
  - Improved Stakeholder communication
- Model & process refined & improved
- PAWSA Workshop Guide revisions

Results: PAWSA Completed



Development of IWRAP

Ports and Waterway Generic Risk Assessment Tool

Channel Width Requirements

Reference Vessel

Course Keeping Error:	25
Vessel Beam:	141
Drift Angles:	34
Navigation:	125
Under Keel Clearance:	2.6
Squat:	2.3

Reference Vessel Under Keel Clearance is less than recomended limits

Other Vessel

Course Keeping Error:	17
Vessel Beam:	68
Drift Angles:	15
Navigation:	125
Under Keel Clearance:	42.6
Squat:	0.4

Common to Both Vessels

Safety Margin:	150.0
Bank Clearance:	30.0
Calculated Channel Width:	730
Channel Ratio:	1.64

Probability

Good to Moderate Weather

Meetings Per Year:	62.21
Potential Proability of Collision Per 10,000:	30.4829
Potential Proability of Grounding Per 10,000:	98.9139

4.57 Collisions Per Year and
14.84 Groundings Per Year
for this section of waterway.

Moderate to Poor Weather

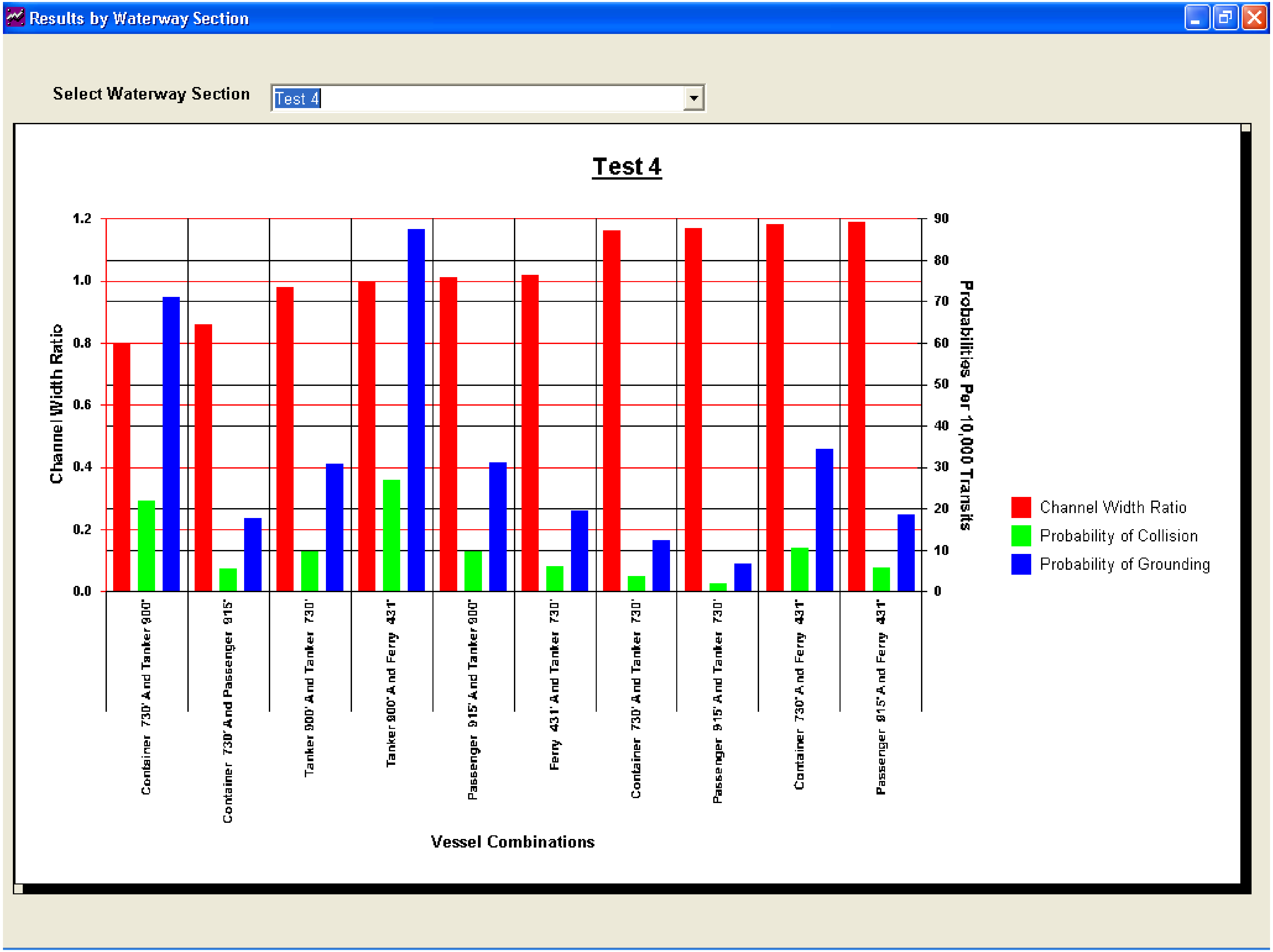
Meetings Per Year:	3.41
Potential Proability of Collision Per 10,000:	1.6709
Potential Proability of Grounding Per 10,000:	5.4219

0.25 Collisions Per Year and
0.81 Groundings Per Year
for this section of waterway.

Total Probability

Potential Proability of Collision Per 10,000:	32.15
Potential Proability of Grounding Per 10,000:	104.34

4.82 Collisions Per Year and
15.65 Groundings Per Year
for this section of waterway.


Results by Waterway Section
Select Waterway Section
Test 4
Test 4
Channel Width Ratio
Probabilities Per 10,000 Transits
1.2
1.0
0.8
0.6
0.4
0.2
0.0
90
80
70
60
50
40
30
20
10
0
Container 730' And Tanker 900'
Container 730' And Passenger 915'
Tanker 900' And Tanker 730'
Tanker 900' And Ferry 431'
Passenger 915' And Tanker 900'
Ferry 431' And Tanker 730'
Container 730' And Tanker 730'
Passenger 915' And Tanker 730'
Container 730' And Ferry 431'
Passenger 915' And Ferry 431'
Vessel Combinations
Channel Width Ratio
Probability of Collision
Probability of Grounding

History

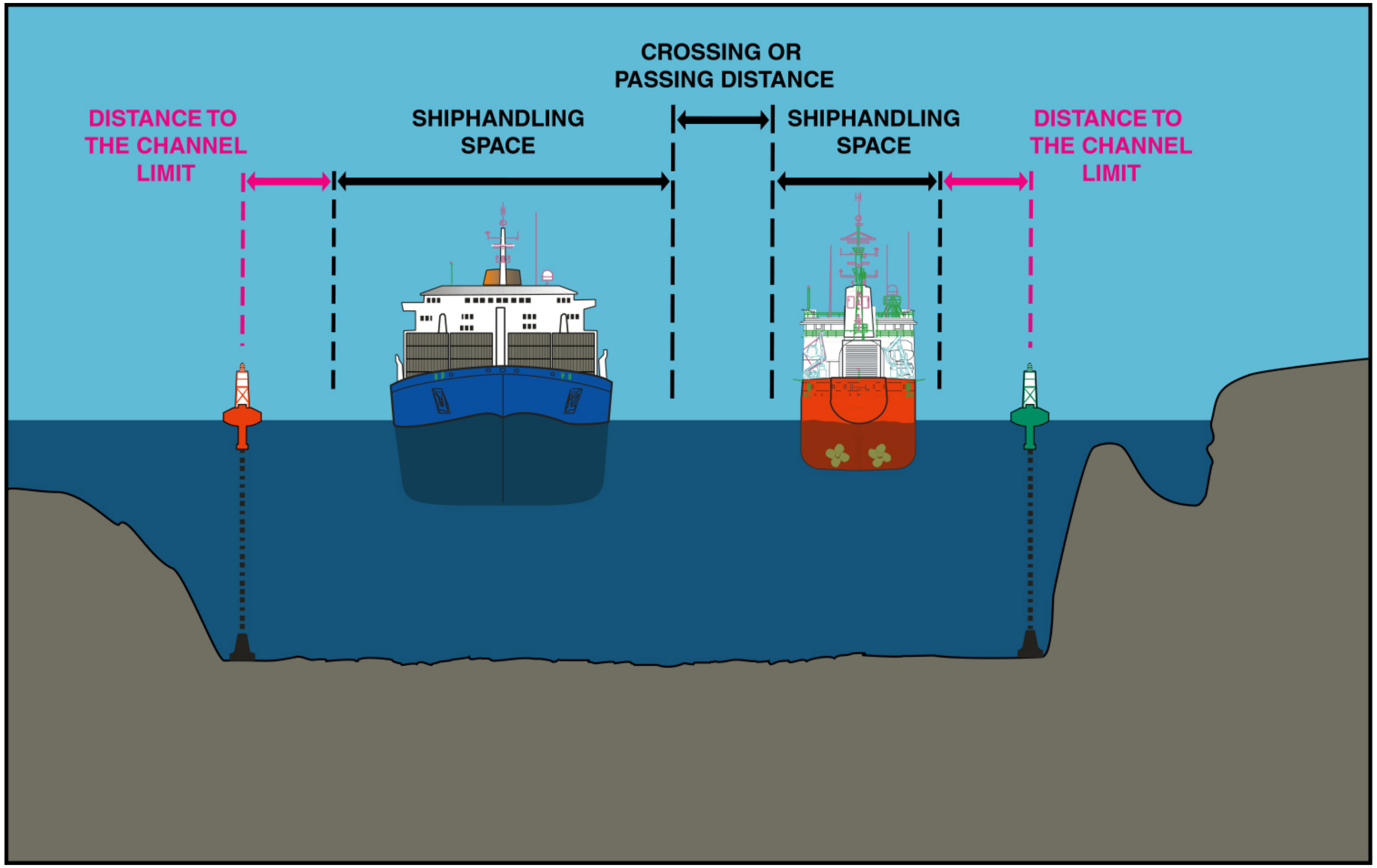
- The MSD was introduced at the Halifax meeting of the working group of the IALA Risk Management Group
- The MSD covered a significant number of the of the group's concerns
- The missing elements were collision and grounding probabilities

MSD - Purpose

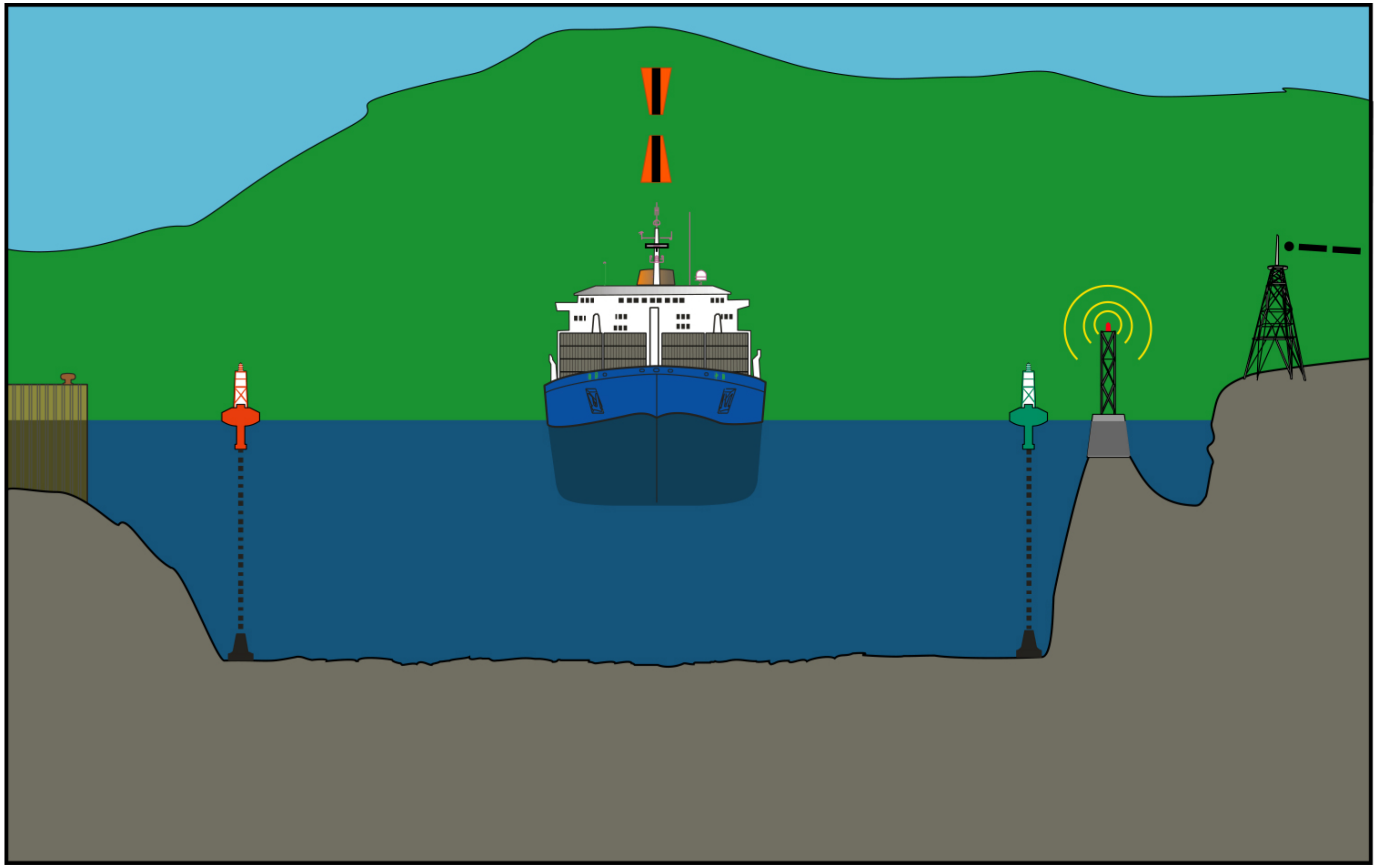
Determines minimum safe channel width based on:

- Vessel size (PIANC)
- Angle of turn (PIANC)
- Quality of position from the mix of aids to navigation provided (Marine Aids Study)
- Channel geophysical conditions (PIANC)

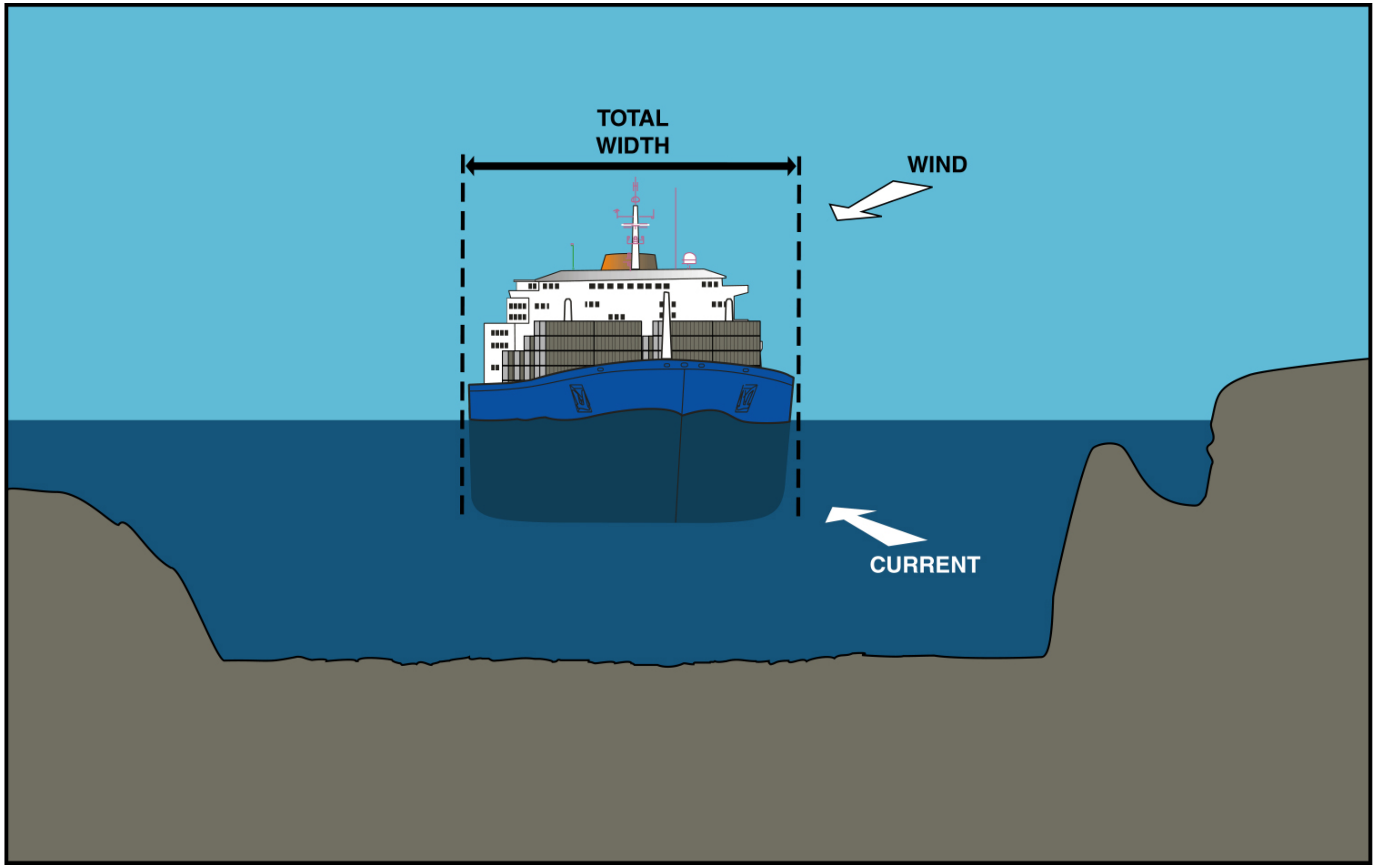
How the MSD Works
Selecting Vessels



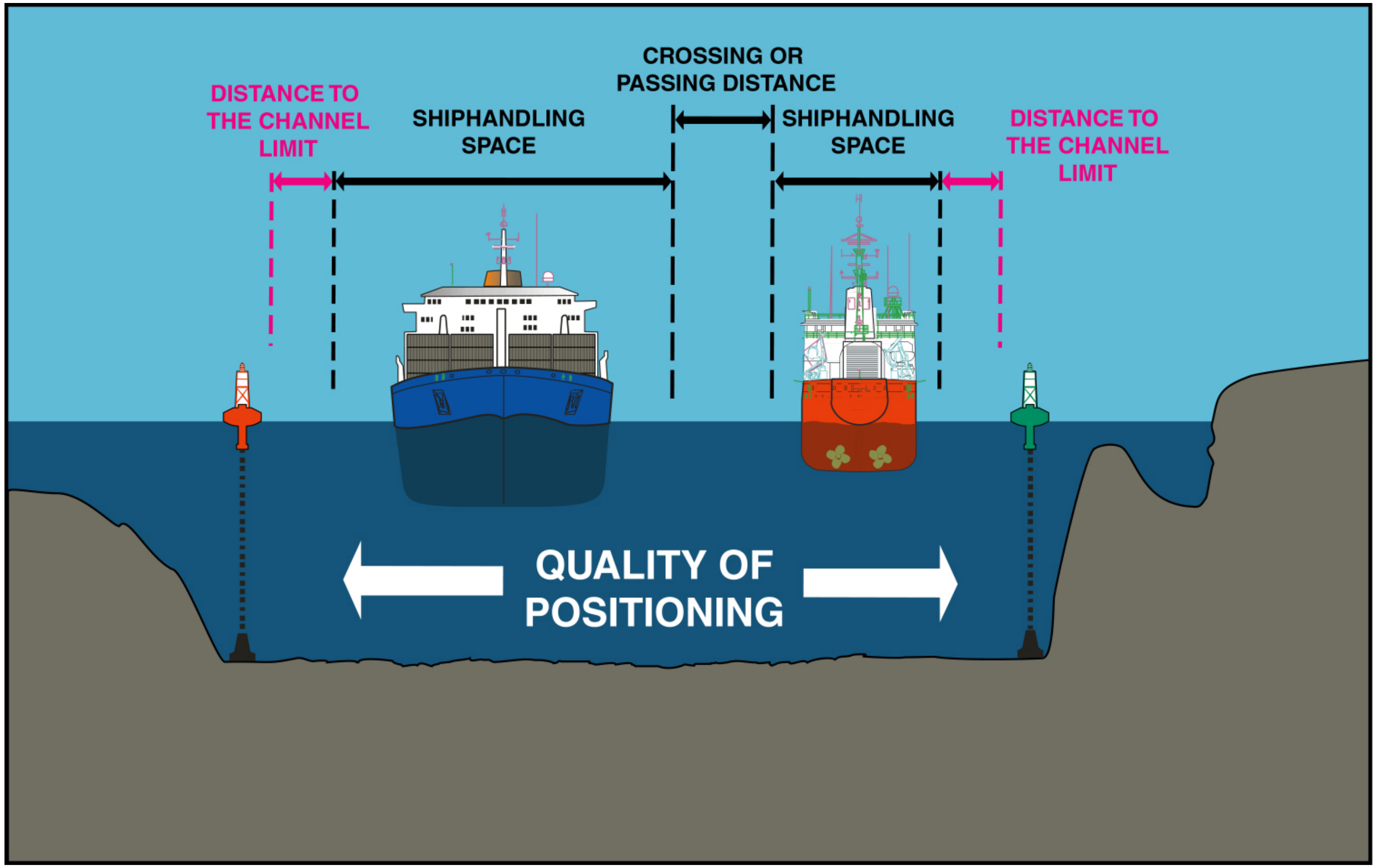
Select Aids to Navigation



Derive the Effects of Wind and Current



Quality of Positioning



MSD - Output

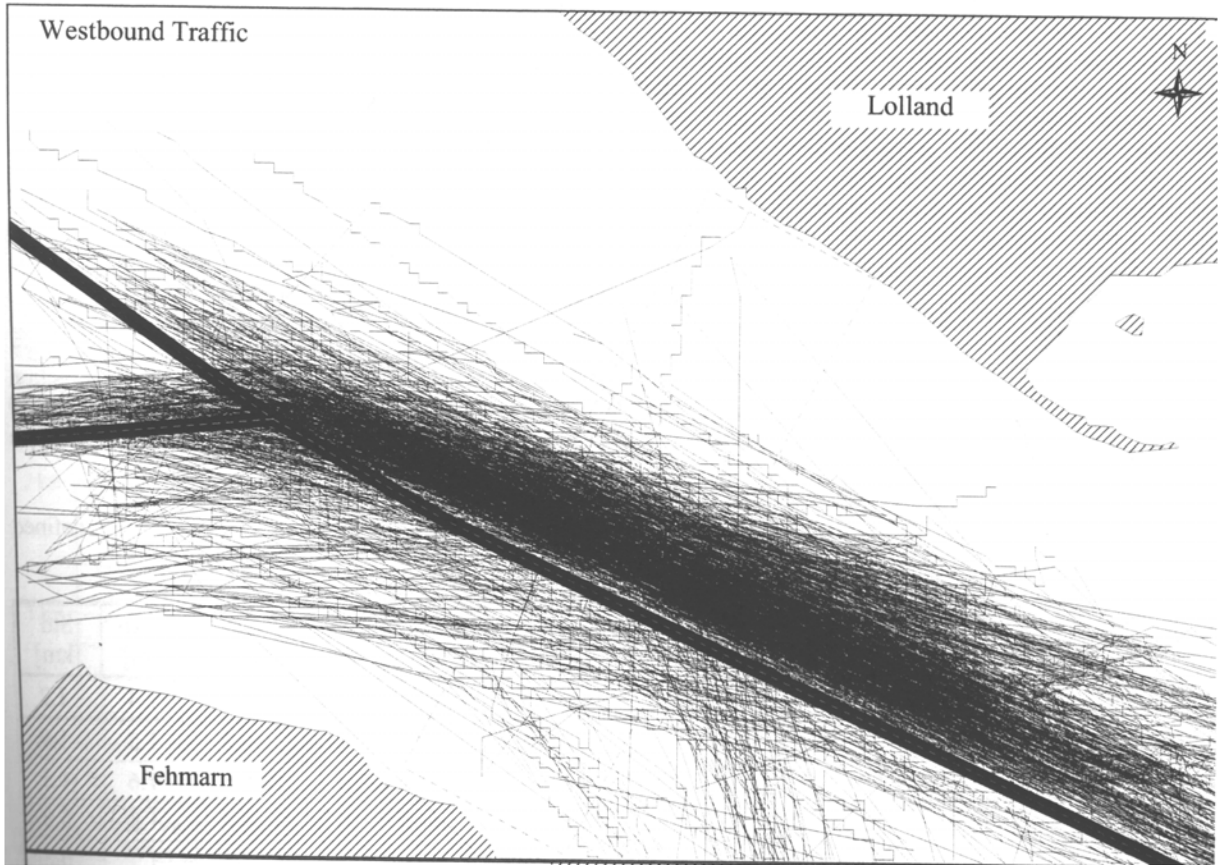
A ratio is developed using the MSD minimum channel width and the actual channel width.

- If the ratio is greater than 1.0 then the channel is considered to be adequate
- If the ratio is less than 1.0 then the Mariner should proceed with a heightened degree of awareness

Development of Probability Formulas

- Actual vessel track information is gathered
- A histogram is built based on the track information
- The distribution of the vessel tracks are then quantified in terms of the Standard Deviation (STD)

Fehmarn Belt – Westbound



Fehmarn Belt – Eastbound

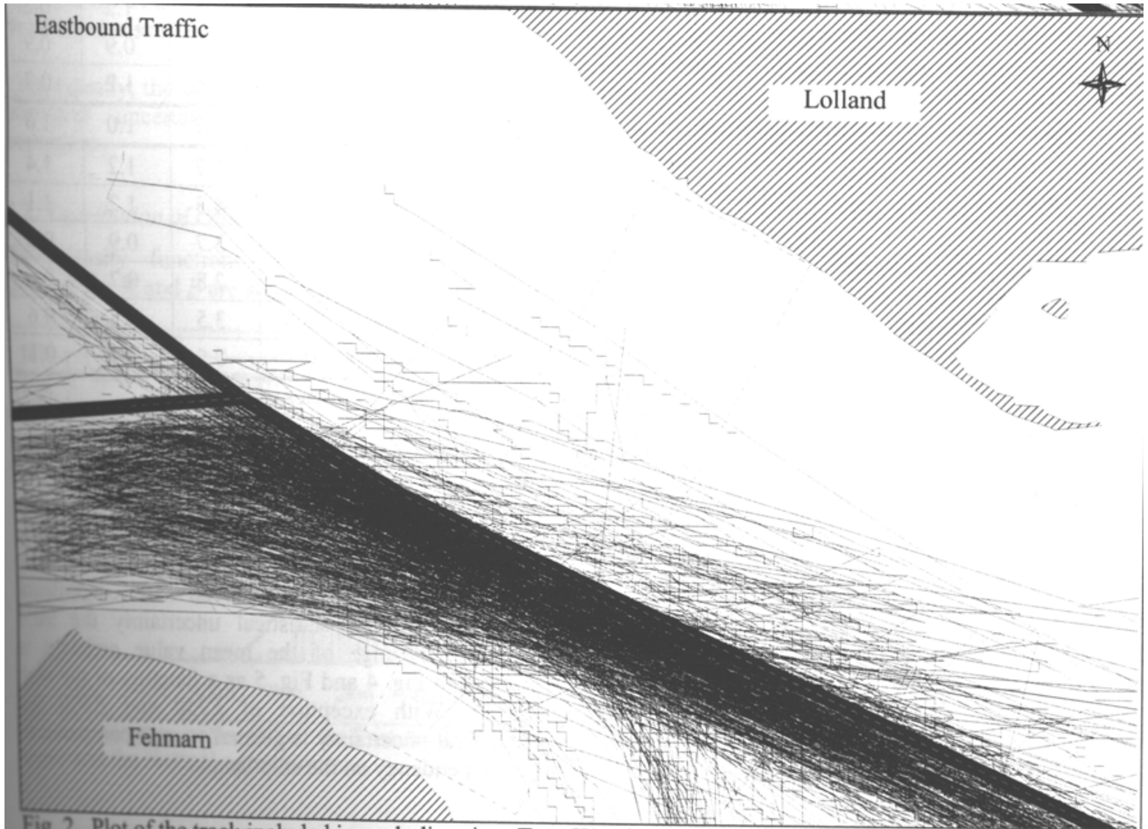


Fig. 2. Plot of the track included in each direction. Top: Westbound passages, Bottom: Eastbound passages

Histogram for Eastbound Tracks

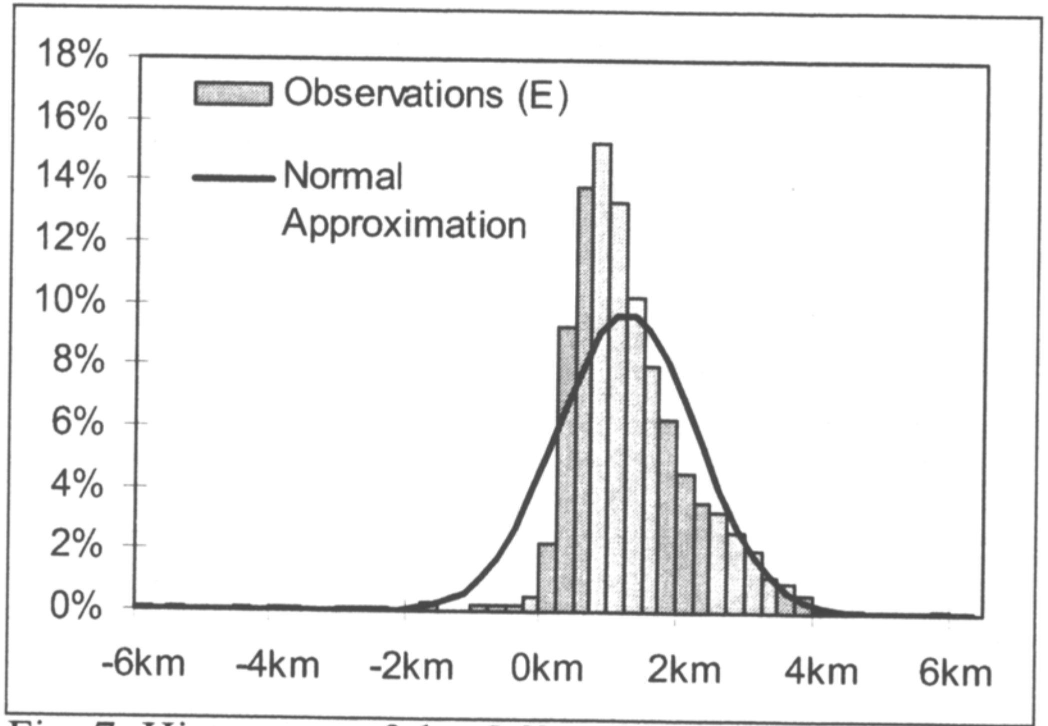


Fig. 7. Histogram of the Offset for West-to-East passages and the Normal approximation.

Histogram for Westbound Tracks

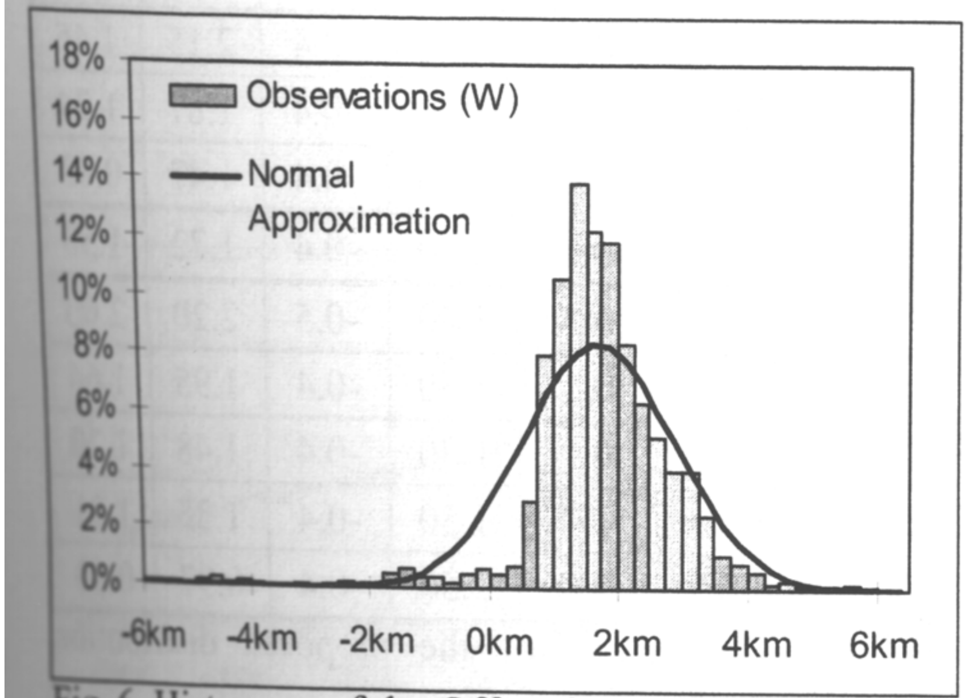


Fig. 6. Histogram of the Offset for East-to-West passages and the Normal approximation.

Moving the MSD Forward

- Work was started on the inclusion of Dr. Pedersen's formulas
- A new interface was built and the name was changed to IWRAP
- Requests for traffic and accident data were also sent out

Probability of Collision

- Probability of collision
  - Pcol = Pc x Na
  - Pc = Causation Factor
    - Constant derived from Dr. Fujii's work
  - Meetings per year (Na)

$$N_a = \frac{1}{\sqrt{2\pi}} L_w \frac{Q_i Q_j}{V_i V_j (\#sec/yr)^2} (V_i + V_j)(B_i + B_j) \frac{1}{\sqrt{(\sigma_i)^2 + (\sigma_j)^2}} e^{-\left(\frac{u^2}{2((\sigma_i)^2 + (\sigma_j)^2)}\right)} \Delta t$$

Deriving the Standard Deviation

- Several methods were tried to develop a “Floating” STD
- The STD had to change from a “Rule of Thumb” (X% of channel width) to something that reflected the changes made to the channel.
- STD = MSD Ratio X Channel Width

Floating STD Benefits

With the current methodology in place any changes to Aids to Navigation, vessel size, vessel speed, traffic volume, channel width, channel length, wind, and current are reflected instantly.

IWRAP Outputs

The output is no longer just the channel width ratio, but it also includes:

- Probability of collision per 10,000 transits
- Probability of grounding per 10,000 transits
- Statement that quantifies them into the expected number of occurrences per year.

Deviations From Reality

IWRAP predicts higher collision rates than what historical data shows.

Reasons:

- Analysis used the boundaries of the of the shipping lane instead of the available channel width
- IWRAP deals with the interaction of theoretical domains without human intervention

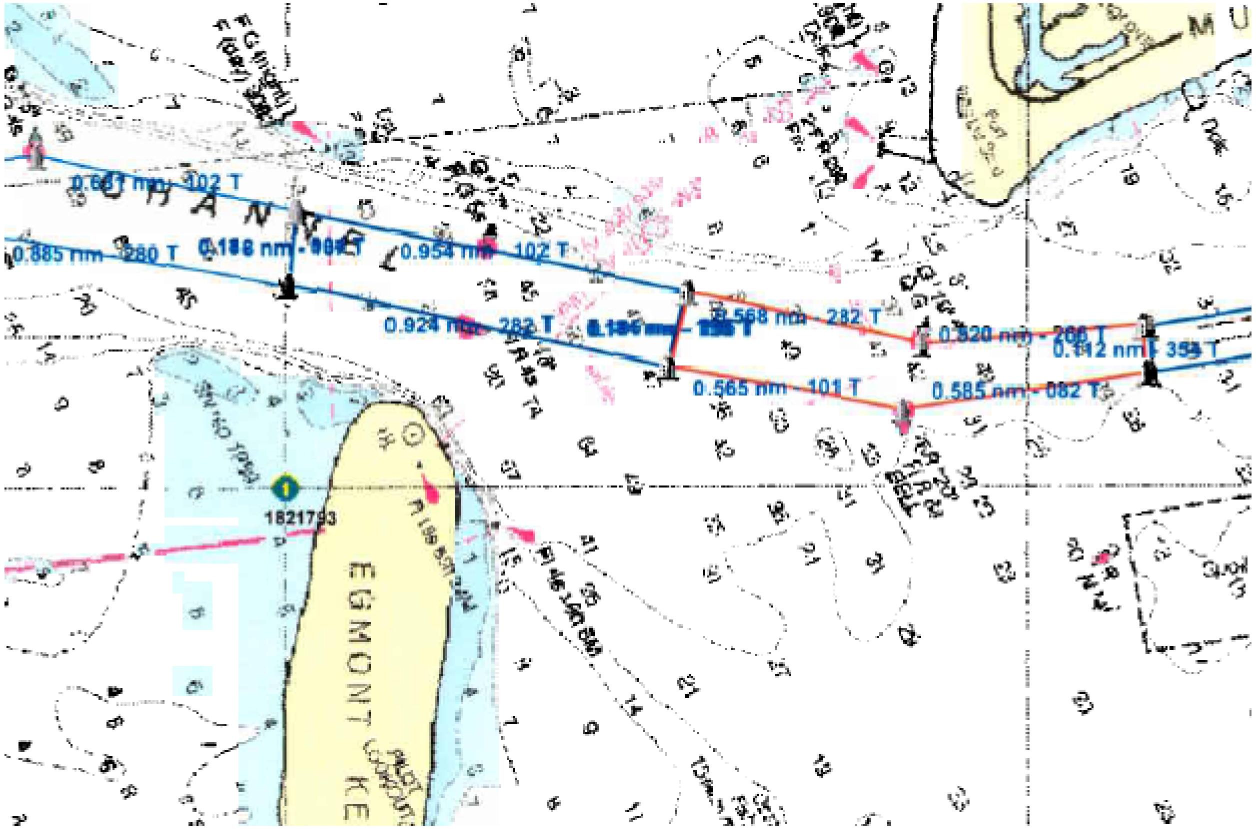
Selecting Vessels

- Vessels must be representative of the population
  – I.e. 730’ bulk carrier with 2600 transits and a 950’ Cruise ship with 3200 transits. Together they represent X% of total transits in the area.
  – Do not use the worst case vessel to represent the whole population if there is a mix of vessel types and sizes.

Initial Results – Tampa Bay

- Historical accident level within the Tampa bay area is relatively low
- Only three incidents occurred within the boundaries of the shipping lane
- Largest paring of most capable vessels only represents 45 percent of the traffic in the Tampa area

Mullet Key Bend



Tampa Bay – Mullet Key Bend Case 1

- Actual vessel transits 1430 each way
  - 36% of the total annual transits
  - Container 730' + Passenger 915'
- Probability:
  - 0.37 Collisions Per Year
  - 1.2 Groundings Per Year
- Channel Width Ratio was 0.69

Tampa Bay – Mullet Key Bend Case 2

- Actual vessel transits 1792 each way
  - 45% of the total annual transits
  - Container 730' + Small Freighter 150'
- Probability:
  - 0.4 Collisions Per Year
  - 1.31 Groundings Per Year
- Channel Width Ratio was 1.02

Initial Results – Bosporus

- Historical accident level within the Bosporus area is relatively high
  - 15 incidents occurred in one year
- Largest paring of most capable vessels represents 80 percent of the traffic
- Worst Case vessels only accounts for 6% of the traffic

Naramata Entrance Section 2 Case 1

- Actual vessel transits 1500 each way
  - 6% of the total annual transits
  - 1074’ Tanker + 915’ Passenger
- Probability:
  - 0.1 Collisions Per Year
  - 0.2 Groundings Per Year
- Channel Width Ratio was 3.33

Naramata Entrance Section 2 Case 2

- Actual vessel transits 18,800 each way
  - 80% of the total annual transits
  - 347’ Container + 150’ Freighter
- Probability:
  - 14.1 Collisions Per Year
  - 45.48 Groundings Per Year
- Channel Width Ratio was 3.94

Copenhagen Meeting

- Methodologies were discussed to capture “Human Element”
- IWRAP now considers the influences of:
  - Four Levels of VTS
  - Pilots onboard vessels
- Results now have a much tighter correlation between theoretical and reality

Initial Conclusions - 1

Minimum channel width by itself is not a sole factor in the determination of the potential risk to navigation in a waterway.

Other considerations are:

- Vessel size and type
- Traffic density

Initial Conclusions - 2

Although total traffic density is a major factor it is more important to consider the sample populations that represent the various configurations of vessels that may transit through a section of waterway.

- Worst Case vessels cannot be applied to the total population if there is a mix of vessel types and sizes.

Initial Conclusions - 3

IWRAP can show the impact of aids to navigation within a channel by rerunning the scenario with different combinations of aid configurations and observing the changes in Pcol and Pground.

- Given several Aid to Navigation scenarios, one could possibly justify a more expensive option if it was shown to significantly reduce risk.

Next Steps

- IWRAP will be applied to more sections of the Bosporus, Tampa Bay, and the St. Lawrence River.
- IALA is selecting a new waterway to test IWRAP
- Enhancements will be made to the existing interface:
  - Automating multi vessel analysis
  - Interface will be multilingual