



**TEXAS A&M UNIVERSITY
GALVESTON CAMPUS.**

PORT OPERATIONS, ADMINISTRATION AND ECONOMICS



1. Defining Seaports

MARA 416

Professor: Dr. Jean-Paul Rodrigue

Course Outline

- 1. Defining Seaports
- 2. Economic, Social and Environmental Value of Seaports
- 3. Seaports: Demand and Supply Determinants
- 4. Ports, Maritime Shipping and International Trade
- 5. Port Hinterlands
- 6. The Evolution of Ports
- 7. Port Authorities
- 8. Port Terminals
- 9. Port Labor

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- B. Typology of Seaports
- C. Port Systems



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A. Defining Seaports

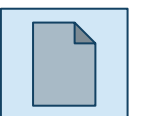
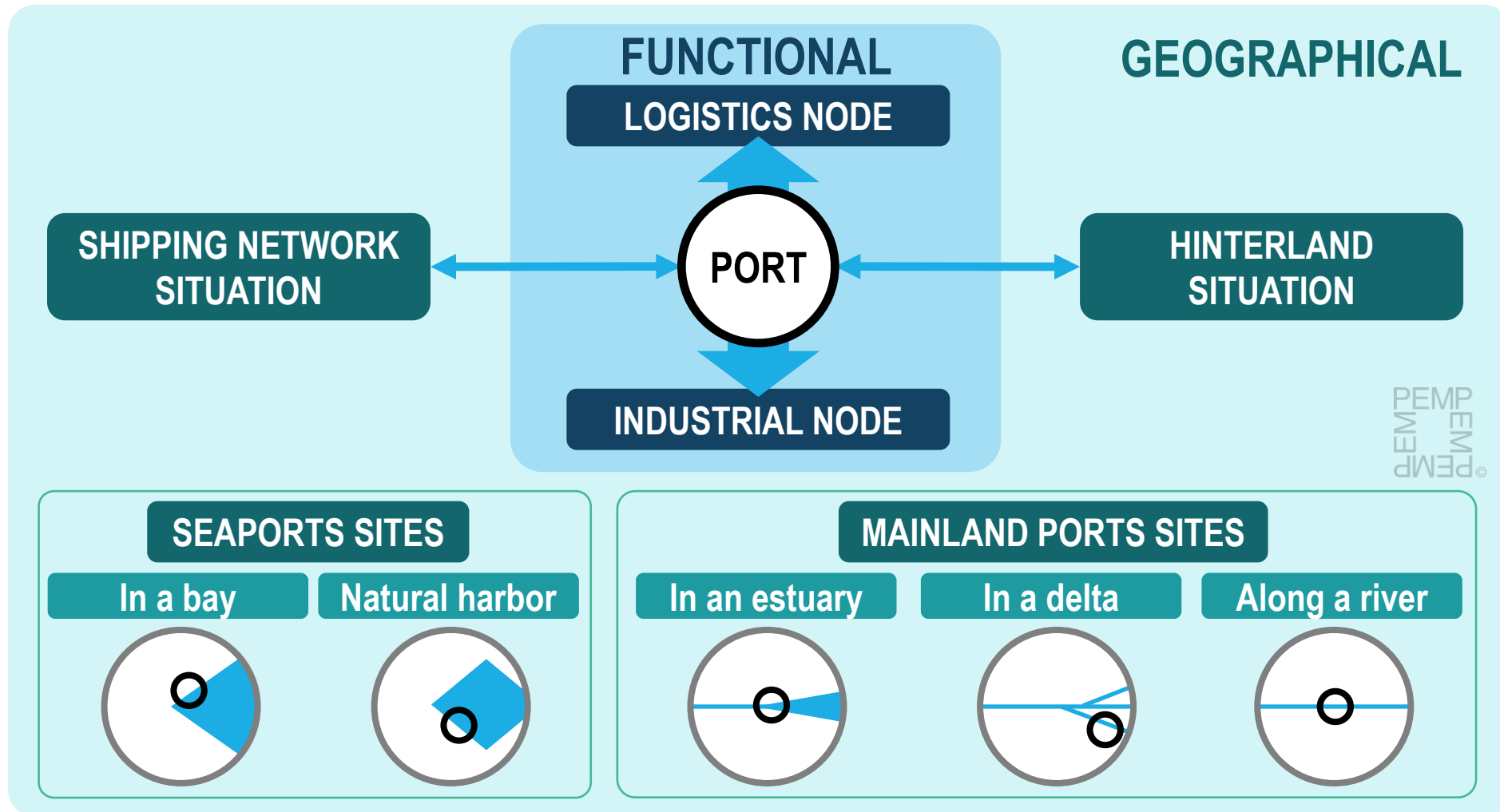


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1. What is a Seaport

- *A seaport is a logistic and industrial node in global supply chains with a strong maritime character and a functional and spatial clustering of activities linked to transportation, transformation, and distribution. It acts as an interface between maritime and inland systems of circulation.*

Defining the Seaport



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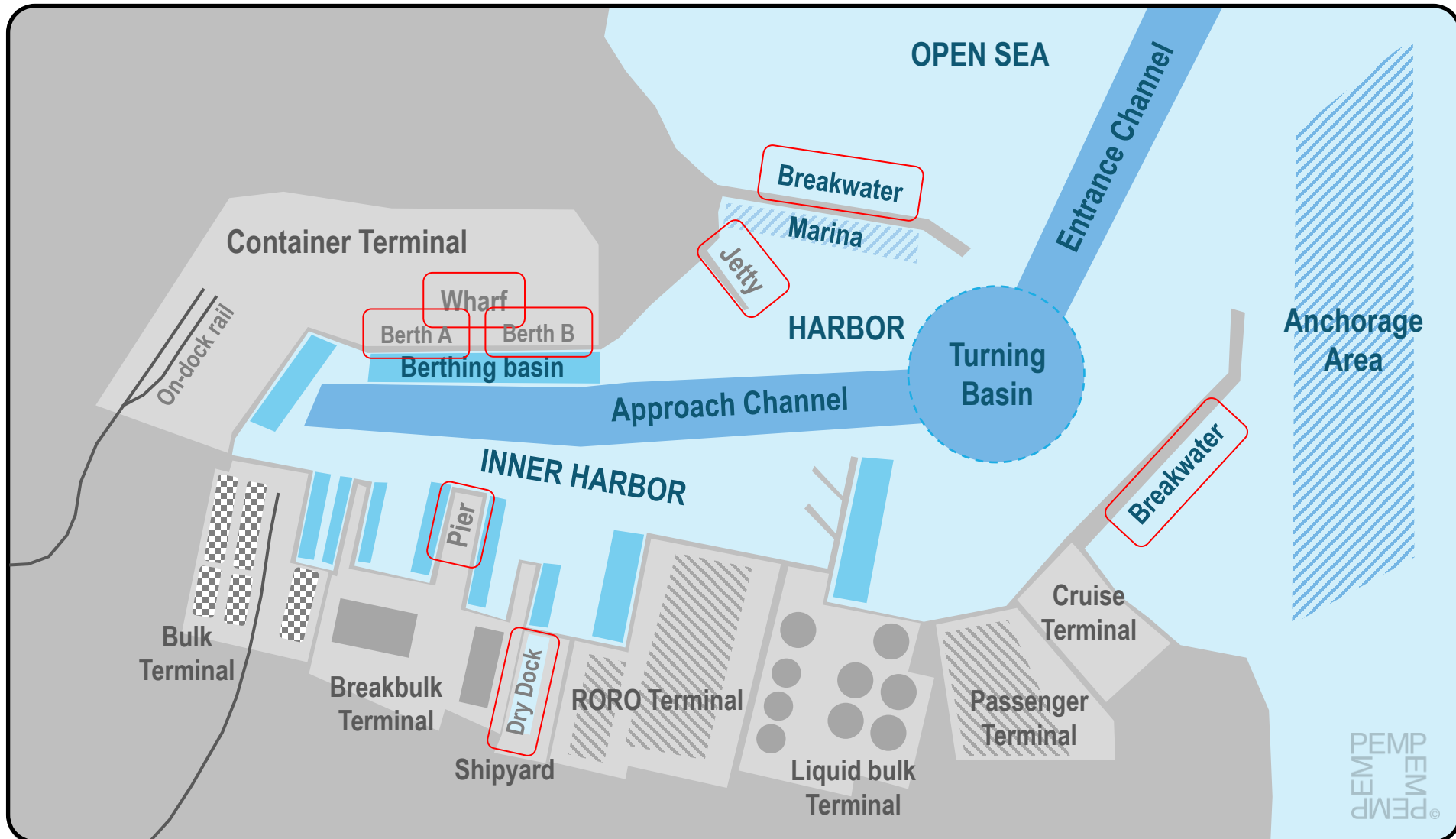
Defining the Seaport

- Geographical elements
 - Situation:
 - Relative position of the port in relation to other ports serviced through shipping networks and its hinterland.
 - Reflects how the port is connected to maritime and inland circulation systems.
 - Site:
 - Physical characteristics of the port, such as its nautical profile (depth, access channel) and the land available for port activities.
 - Seaports: Direct access to the sea via a bay or natural harbor.
 - Mainland ports: Access via an intermediary navigation channel.

Defining the Seaport

- Functional elements
 - Logistics node:
 - Added value performed by the port's transportation function.
 - Handling, storage, consolidation, and deconsolidation of cargoes.
 - Industrial node:
 - Activities depending on the port as a platform.
 - Inputs such as raw materials.
 - Distribute outputs such as parts and finished goods.

Main Physical Elements of a Port



PEMP
EM
EM
EM



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Breakwaters and Jetties

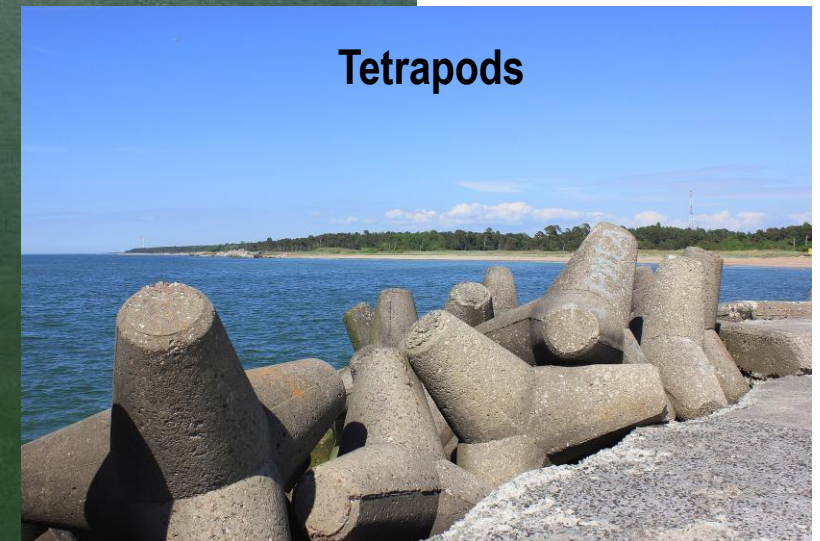
- Breakwaters

- Protect harbors from wave action.
- Reduce sediment buildup in harbor.
- Influence sediment transport patterns along adjacent shores.
- Constructed using large concrete blocks, rubble mounds, or caissons.
- Can be detached (offshore) or shore-connected depending on coastal conditions.

- Jetties

- Extend perpendicular from shore.
- Stabilize inlet channels and prevent shoaling (increase in wave height as it enters in shallow water).
- Some are used as offshore docking facilities for ships.

Rubble Mound Breakwater, Al-Faw, Iraq (14.5 km in length)



Tetrapods

Breakwater at the Port of Zeebrugge, Belgium



Quays, Wharves and Piers

- Quays
 - The physical docking structure.
 - Vertical walls for ships to berth alongside and unload cargo.
 - Constructed using reinforced concrete, steel sheet piles, or gravity structures.
 - Designed to withstand lateral earth and sea pressures and ship impact forces.
- Wharves
 - A lateral structure composed of continuous quays.
 - Extend from shore into deeper water.
 - Equipped with bollards, fenders, and mooring systems for secure vessel docking.
- Piers (or finger pier)
 - Docking structures (quays and wharves) extending into the harbor.
 - Extensions of the terminal facility.
 - A pier can hold facilities such as storage sheds and warehouses.

Finger Piers at the Port of Galveston



Docks and Berths

- Docks
 - Water area where ships are loaded and unloaded.
 - Dry docks allow ship maintenance and repair by pumping out water.
- Berths
 - Specific locations along quays or wharves for vessel mooring.
 - Have a numbering system.
 - A terminal is composed of one or more berths.
 - Specialized berths cater to different vessel types (container, bulk, tanker).
- Dry dock
 - Basins that can be flooded and emptied.
 - Mainly used for the construction, maintenance, and repair of ships.



Natural vs Artificial Harbors

- Natural harbors
 - Present in protected coastal areas (bays, estuaries, deltas).
 - Offer inherent shelter from waves and storms, reducing infrastructure needs.
 - Most natural harbors have been settled.
 - Often have depth limitations.
- Artificial harbors
 - Created through extensive engineering and construction.
 - Require breakwater systems to provide protection.
 - Built to escape depth constraints.

Anchorage and Pilot Boarding Areas

- Anchorages

- Temporary holding areas for ships awaiting berth availability.
- Holding area for ships waiting a new assignment.
- Can restock, change crews and bunker.
- Located in areas with suitable water depths and bottom conditions for anchoring.
- Proximity to navigation channels and potential impacts on other port operations.

- Pilot boarding areas

- Usually outside harbor limits (5 km from entrance channel).
- Leave ample time for pilot to board and go to the bridge.
- Usually by pilot ships (helicopters if conditions are difficult).

Entrance Channel

- Outer access channel
 - Outside breakwater or protected area.
 - Width a function of vessel beam, traffic density, and environmental conditions.
 - Depth accounts for vessel draft, squat effect, and under-keel clearance.
- Design
 - Alignment minimizes cross-currents and provides smooth transitions for ships.
 - Entrance location balances wave exposure, sediment transport, and navigational safety.
 - May incorporate protective structures (breakwaters, jetties) to maintain channel stability.

Turning Basins

- Purpose

- Many port channels are cul-de-sacs.
- Allow large vessels to rotate and change direction within the harbor.

- Design

- Sized based on the length overall (LOA) of the design vessel.
- Controlled depth.
- Maneuvering clearance:
 - 2 LOA is the standard clearance.
 - 1.5 LOA for a ship with bow thrusters.
 - 1.2 LOA for a ship with tug assistance.

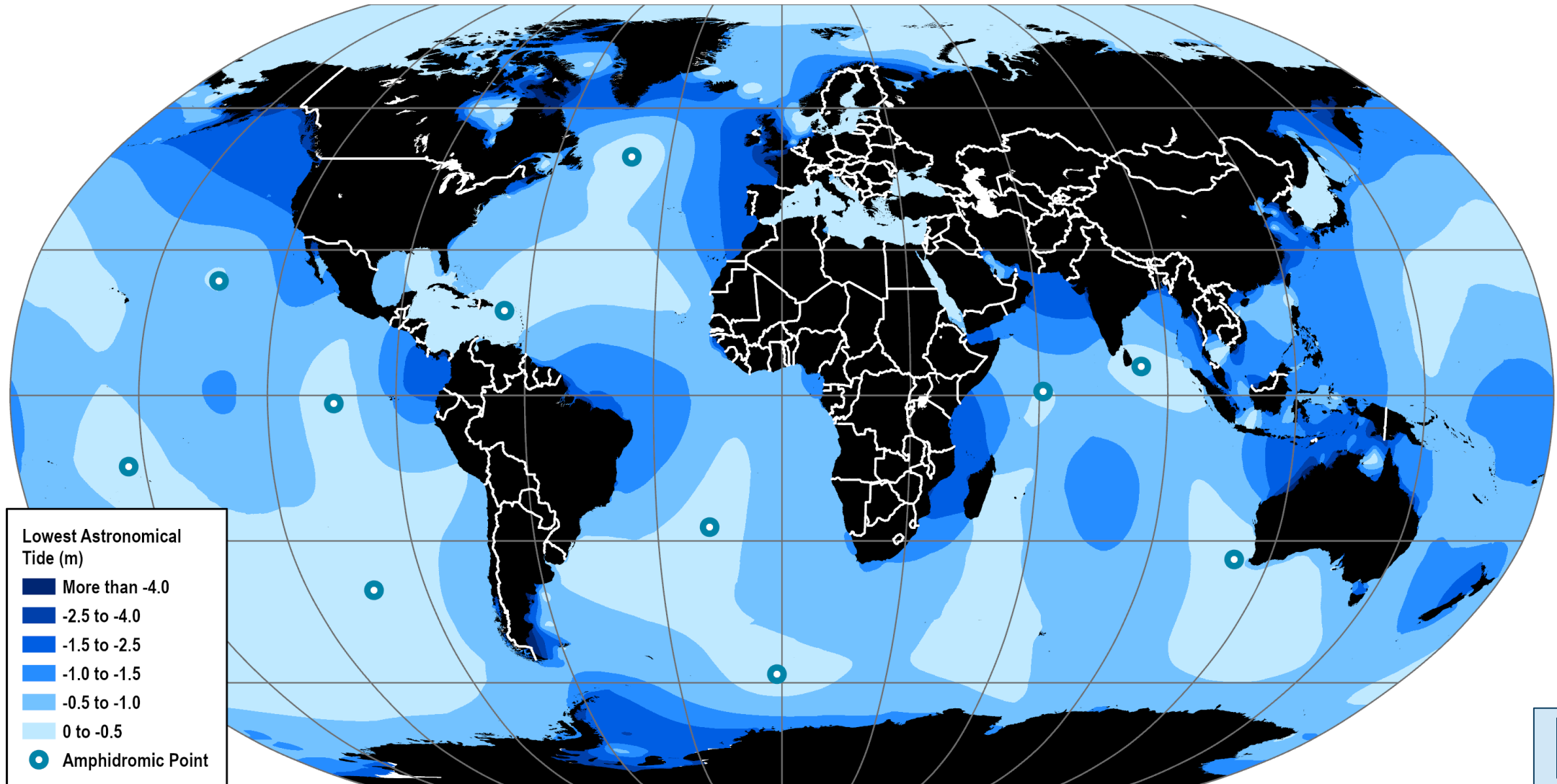
Tug Assisted Turning Basin, Port of Wilmington, North Carolina



Topography and Bathymetry

- Topography
 - Availability of flat land for terminals.
 - Access to the port facilities.
- Water depth
 - Function of the types of vessels allowed to call.
 - Chart datum: The sea level of reference.
 - Lowest Astronomical Tide (LAT):
 - Lowest common water depth, taking into consideration tides.
 - Mean Sea Level in areas of limited tide.
 - Amphidromic point
 - Location where tidal range is nearly zero.
 - Bathymetry is morphodynamical.
 - Sedimentation.

Global Estimated Surfaces of Lowest Astronomical Tide (LAT)



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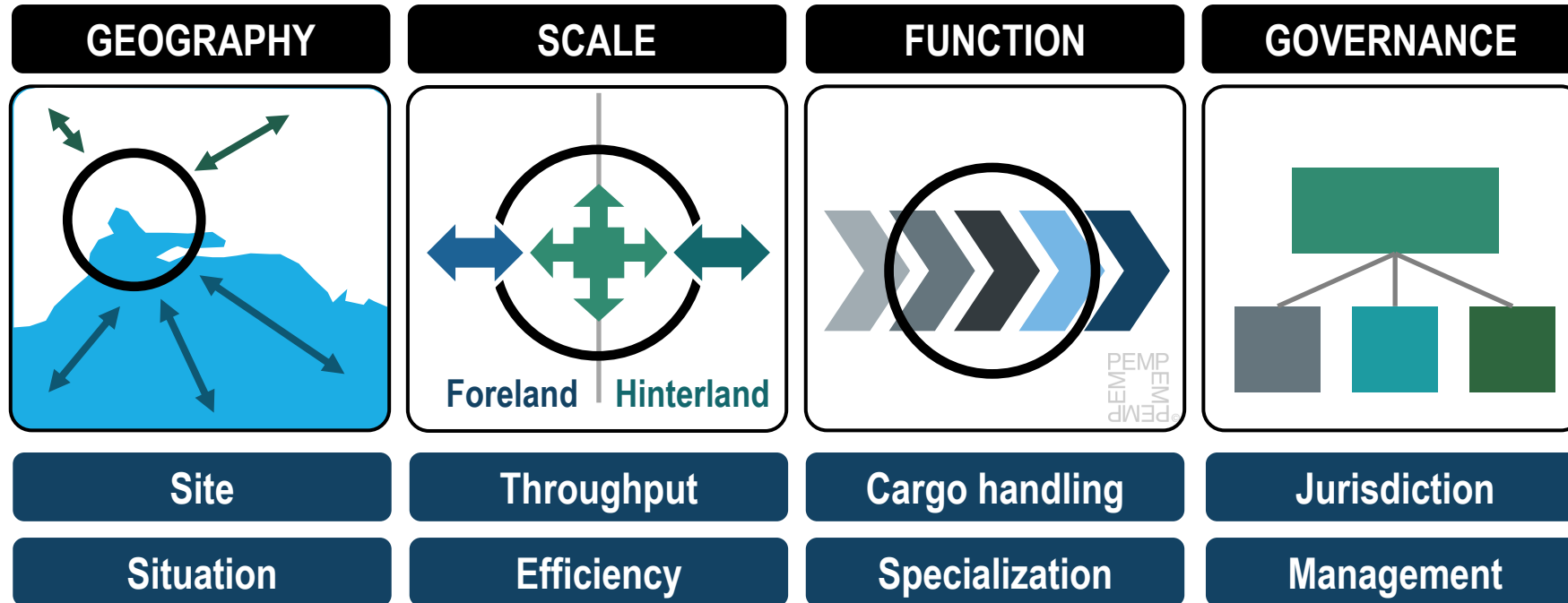


B. Typology of Seaports



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Port Dimensions



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Port Dimensions

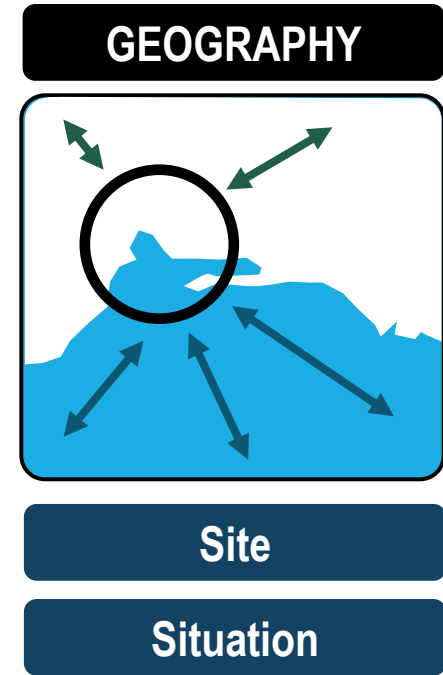
- Geography

- Site:

- Convenient harbor characteristics (such as a protected bay).
 - Supports interface between the maritime and land domains.
 - Can be improved through dredging and land reclamation (capital investments).
 - Expand its surface and the amount of traffic it can handle.

- Situation:

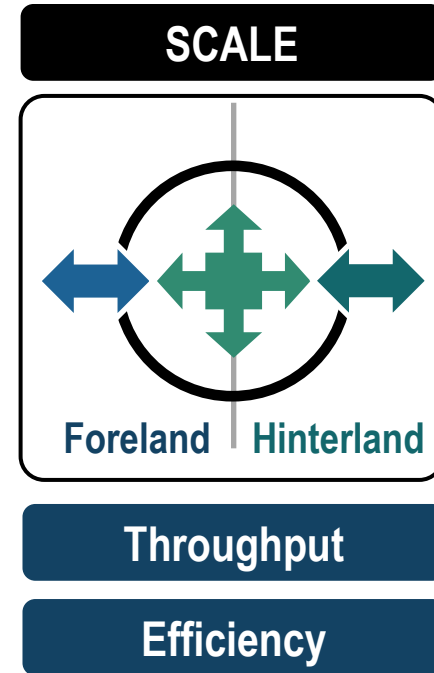
- Can also change in time.
 - Depends on the market it serves and includes manufacturing and consumption areas.



Port Dimensions

- Scale

- The scale of the activities performed at the port.
- The scale of its market coverage.
- Scale characteristics, including the types of traffic it can handle and the throughput.
- Contingent upon:
 - Infrastructure (berths).
 - Superstructure (cranes and yard equipment).
 - Linking the port foreland (the ports it is connected to) and the port hinterland (inland market area).
- Operational efficiency can be improved with changes to land, equipment, and management.



Port Dimensions

- Function

- Adds value to transport and supply chains through cargo handling.
- Historically, heavy industrial activities such as steel mills and petrochemical plants had a propensity to be located within or nearby ports.
- Diversity of port functions associated with specialization forms, such as ports involved in minerals, energy, and containers.
- Large ports tend to be polyfunctional, while smaller ports tend to be monofunctional.

FUNCTION



Cargo handling

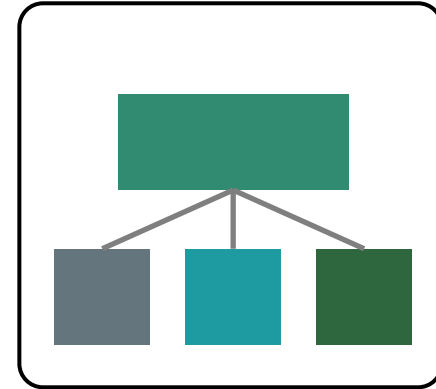
Specialization

Port Dimensions

- Governance

- Well-defined administrative unit that involves land ownership and jurisdiction (what a port can legally do).
- Port authority is a common administrative framework.
- Terminal management and operations are often leased to private companies.
- Port authorities usually have the right to spearhead port development projects and secure funding.

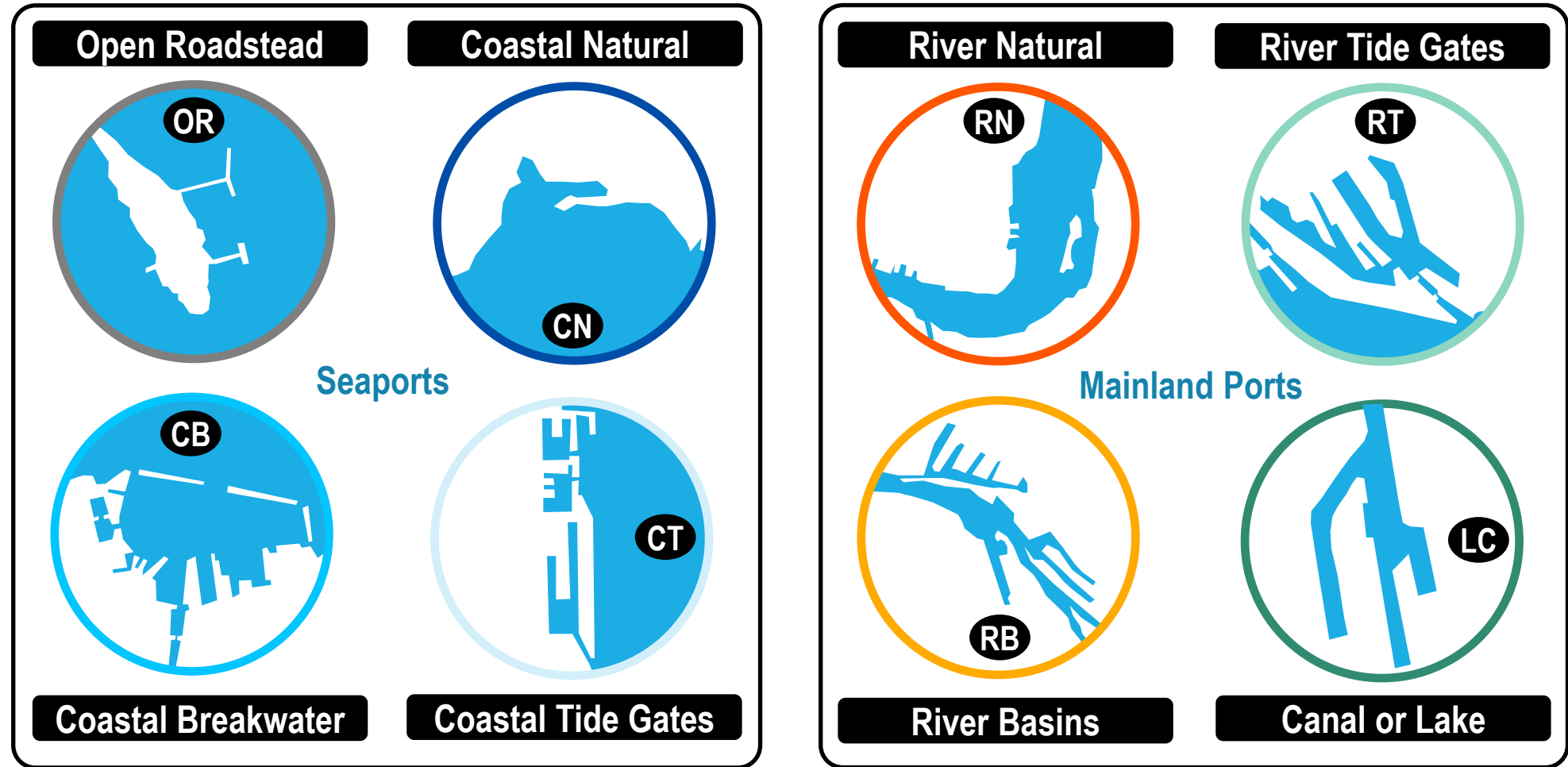
GOVERNANCE



Jurisdiction

Management

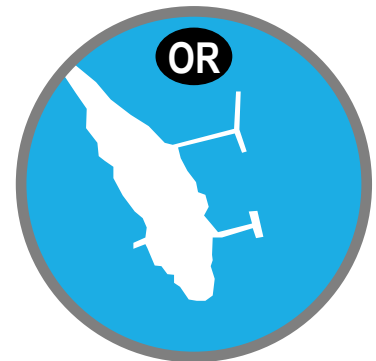
Harbor Types



Open Roadstead (OR): Ras Tanura, Saudi Arabia

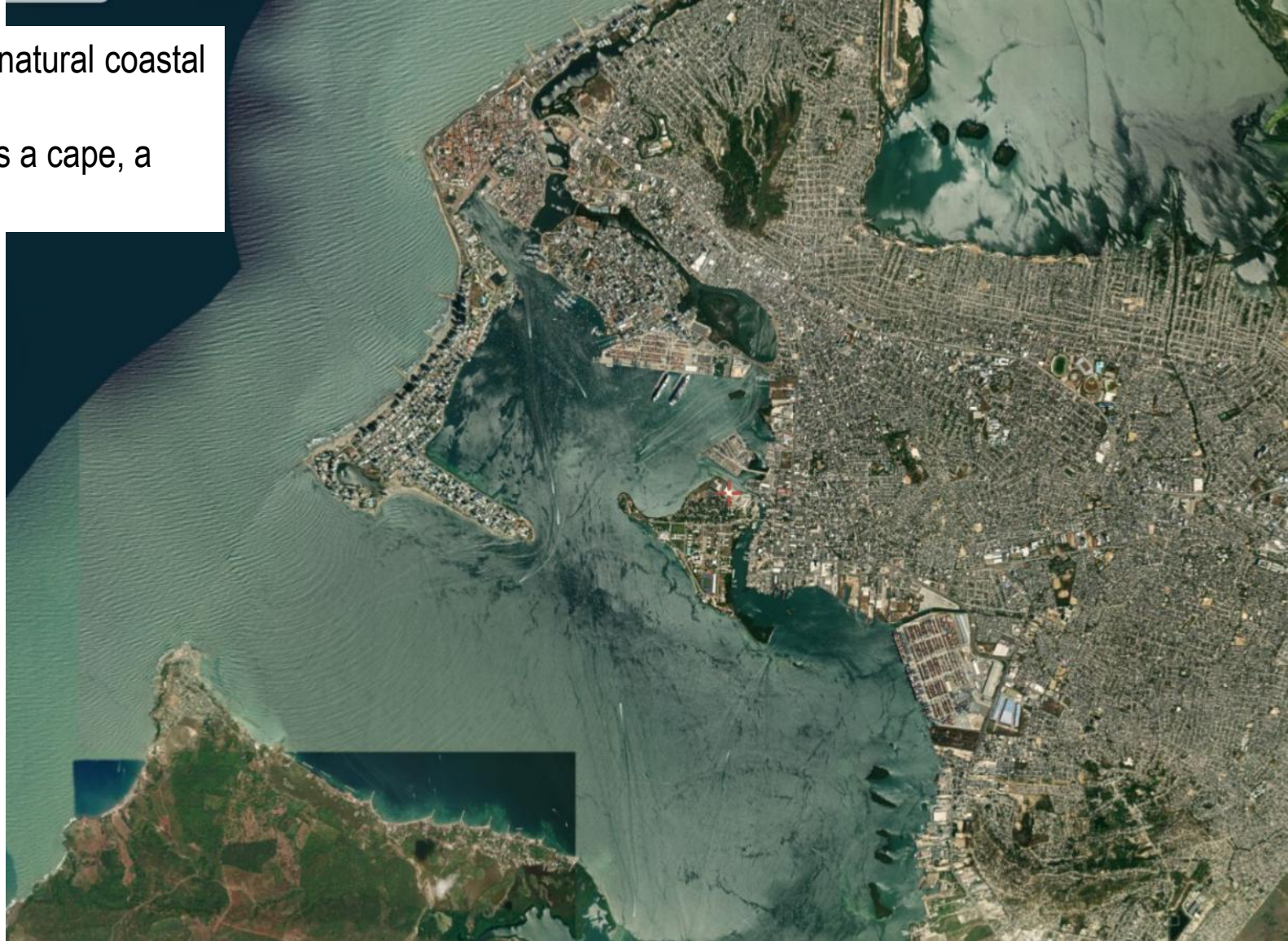


- A harbor with no natural or artificial protection.
- Allowing for a safe anchorage with limited exposure to currents, winds, and tides.
- Built to accommodate very large ships (such as oil tankers) or in a setting with limited tides.
- Sheltering infrastructure is much less required.



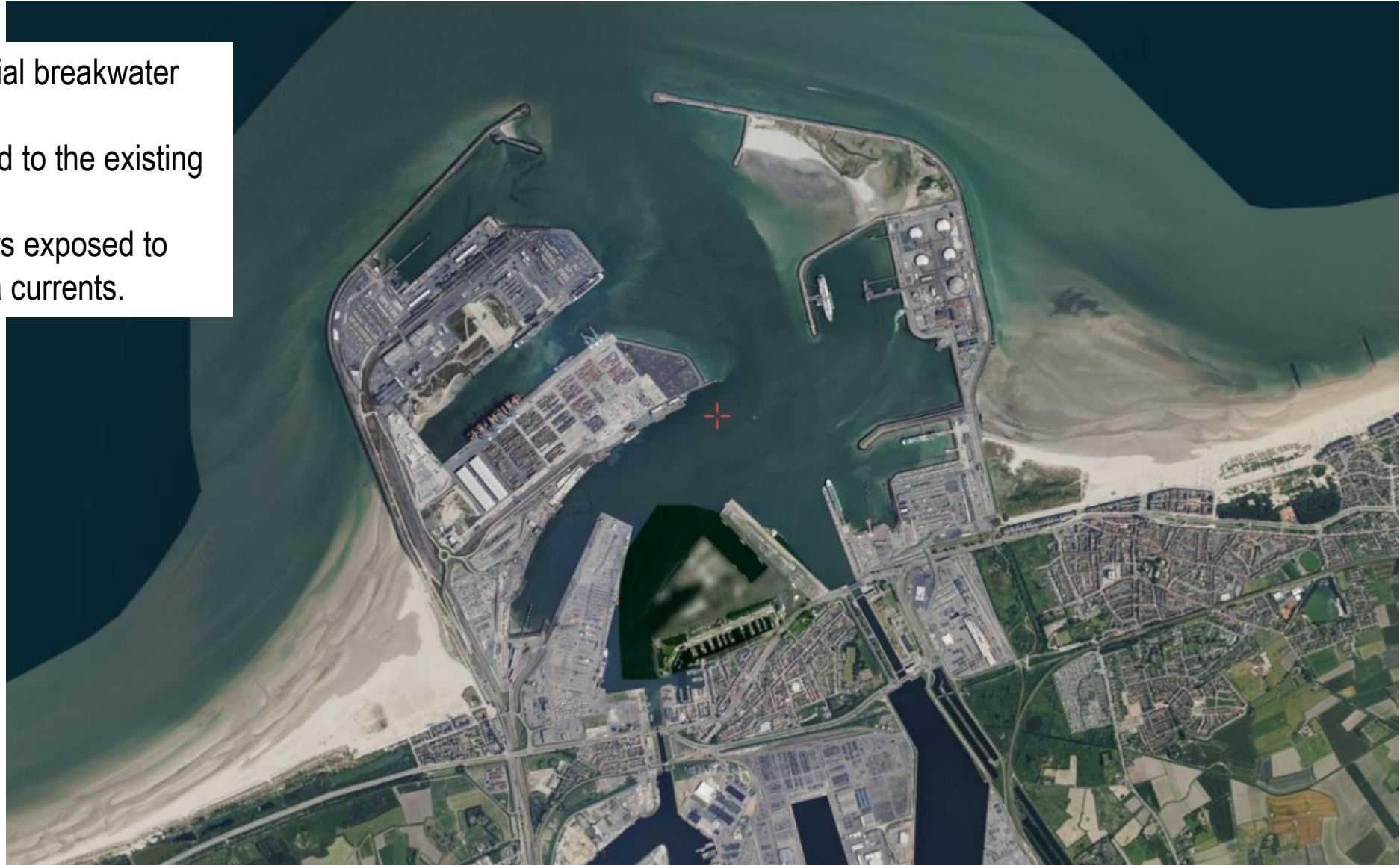
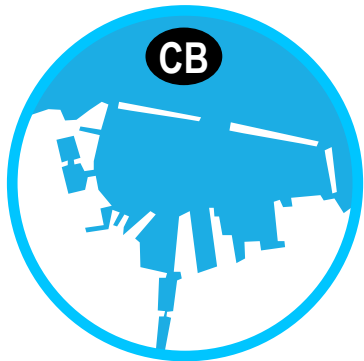
Coastal Natural (CN): Cartagena, Colombia

- Sheltered site, the outcome of a natural coastal profile.
- Creating a natural barrier such as a cape, a reef, or an island.

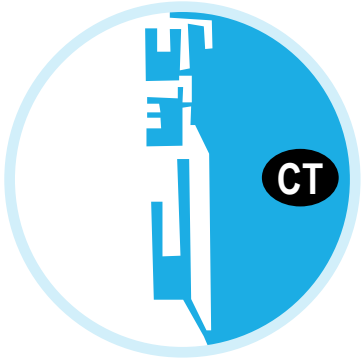


Coastal Breakwater (CB): Zeebrugge, Belgium

- A harbor lying behind an artificial breakwater construction.
- Built from scratch or built to add to the existing natural shelter.
- Particularly the case for harbors exposed to dominant winds, waves, or sea currents.



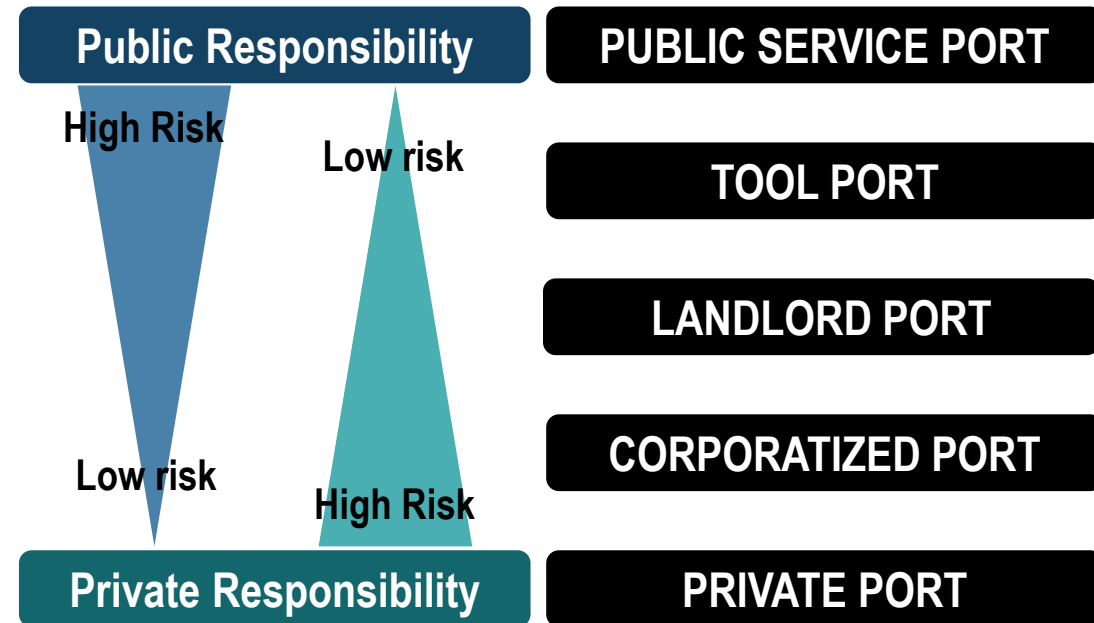
Coastal Tide Gates (CT): Le Havre, France



- Harbor behind a set of locks or other mechanical devices.
- Built to ensure sufficient water levels in the harbor for all tide levels.
- Ships can only enter or exit the port at specific times of the day when water levels are suitable.
- Capital-intensive and are typically located in large ports.

Main Port Governance Models

- Public service ports
 - Sole ownership and control of all port activities.
 - Responsible for investments, operations, and maintenance.
- Tool ports
 - Owns and operates all the port infrastructure and superstructure.
 - Activities, such as cargo handling, are assumed by private companies acting on behalf of the port authority or cargo owners.
- Landlord ports
 - Assumes the planning and development of port infrastructure.
 - Leasing facilities to private operators over long-term concessions.
- Corporatized ports
 - Private shareholding company (public sector often shareholder).
 - Functions similarly to a landlord port.
- Private ports
 - Public sector has limited involvement in port activities.
 - Primarily serving as the regulator and providing services such as customs and pilotage.

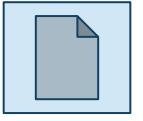


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Port Development

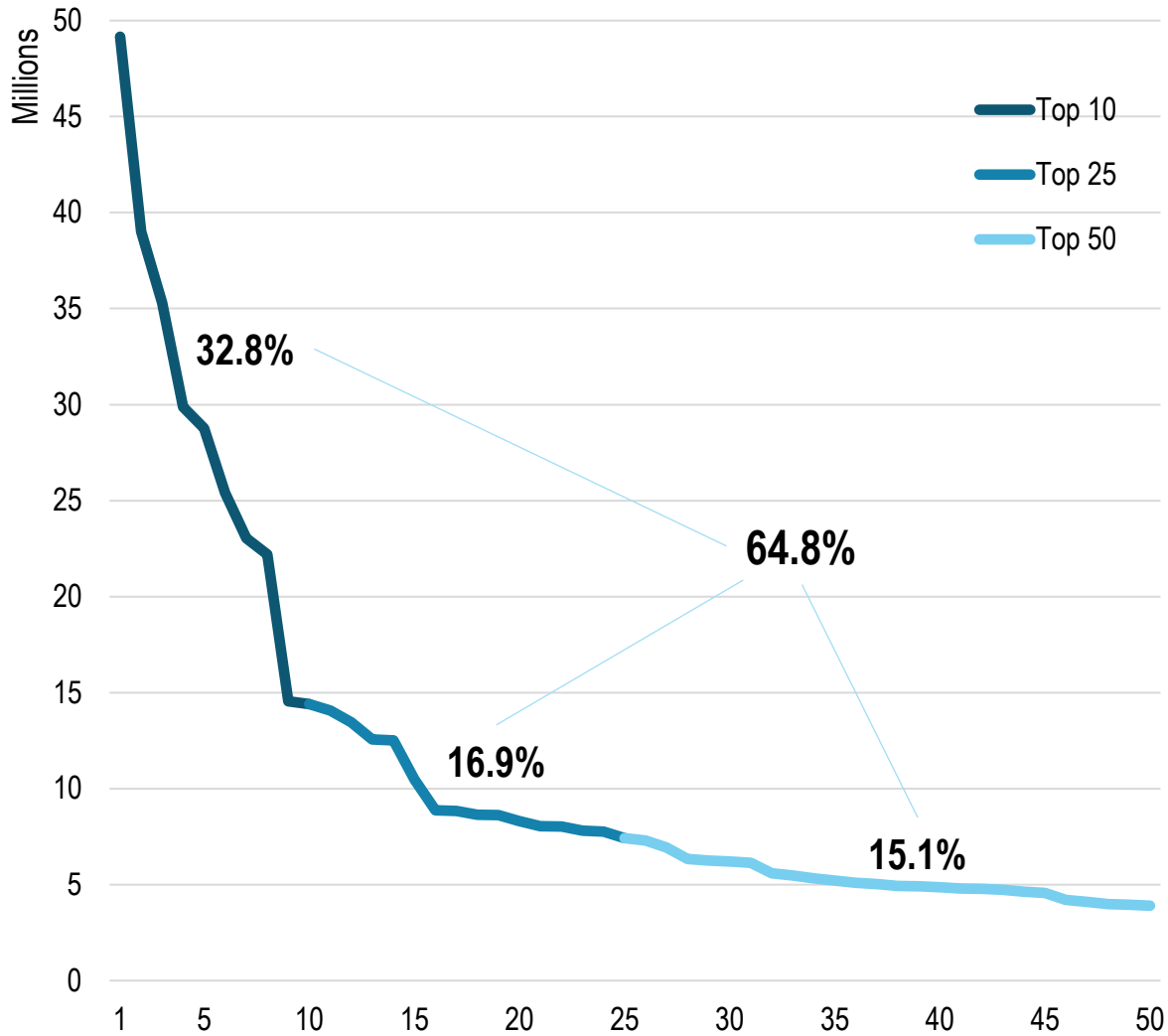
- Evolution of port functions
 - Trade, distribution and industry.
 - Energy hubs.
 - Cruises.
- Port hierarchies
 - From small ports serving a niche market (often a single commodity).
 - Large gateways serving a vast area encompassing a wide range of economic activities.
 - Small number of very large ports account for a significant share of the total traffic.
 - 20 largest container ports accounted for 45.9% of the total traffic.
- Hubs within supply chains
 - Commands freight flows and requires knowledge-intensive coordination activities.
 - Service centers and logistics platforms.

Global Hierarchy of Container Ports

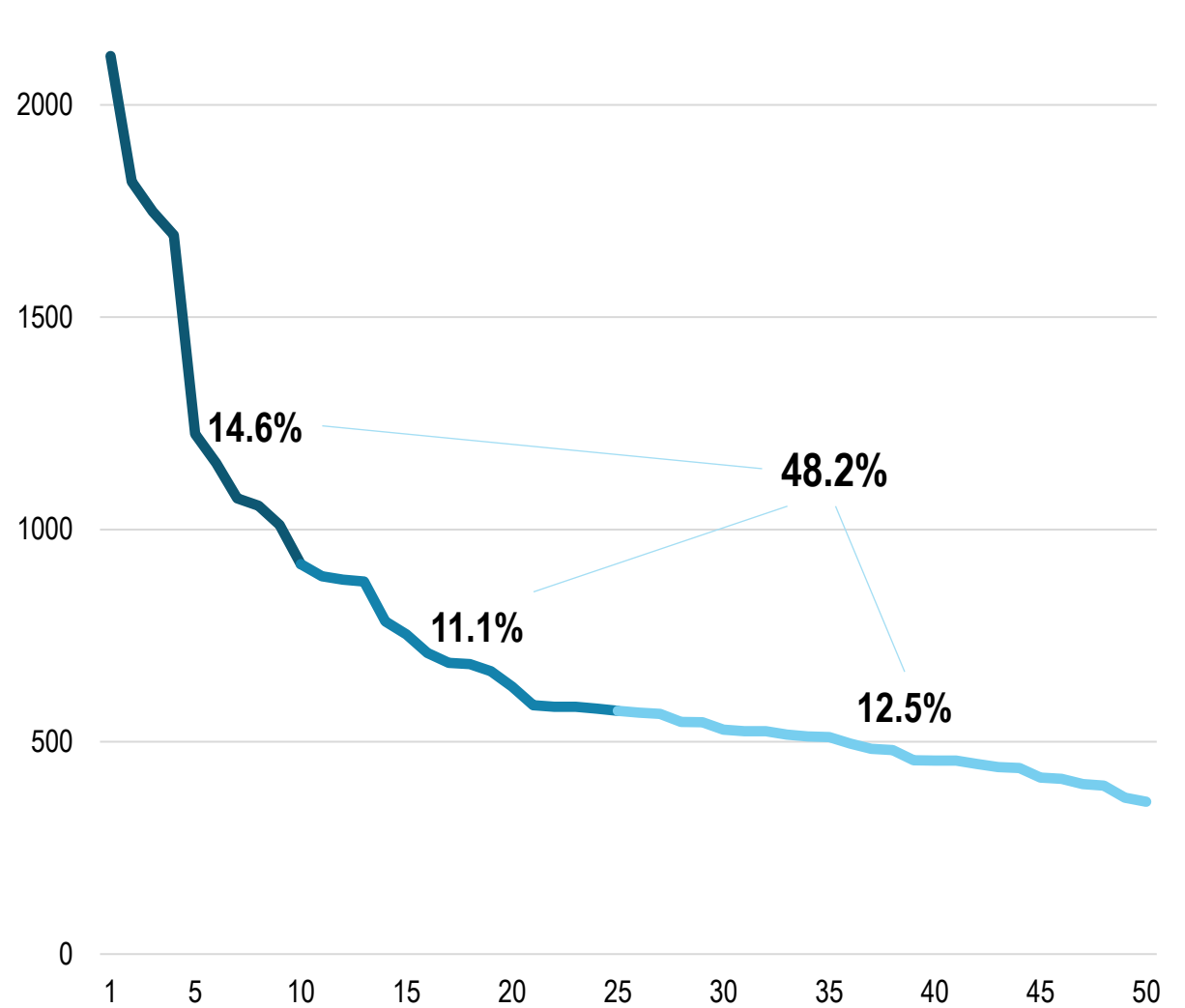


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C. Port Systems

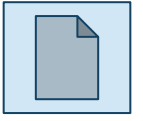


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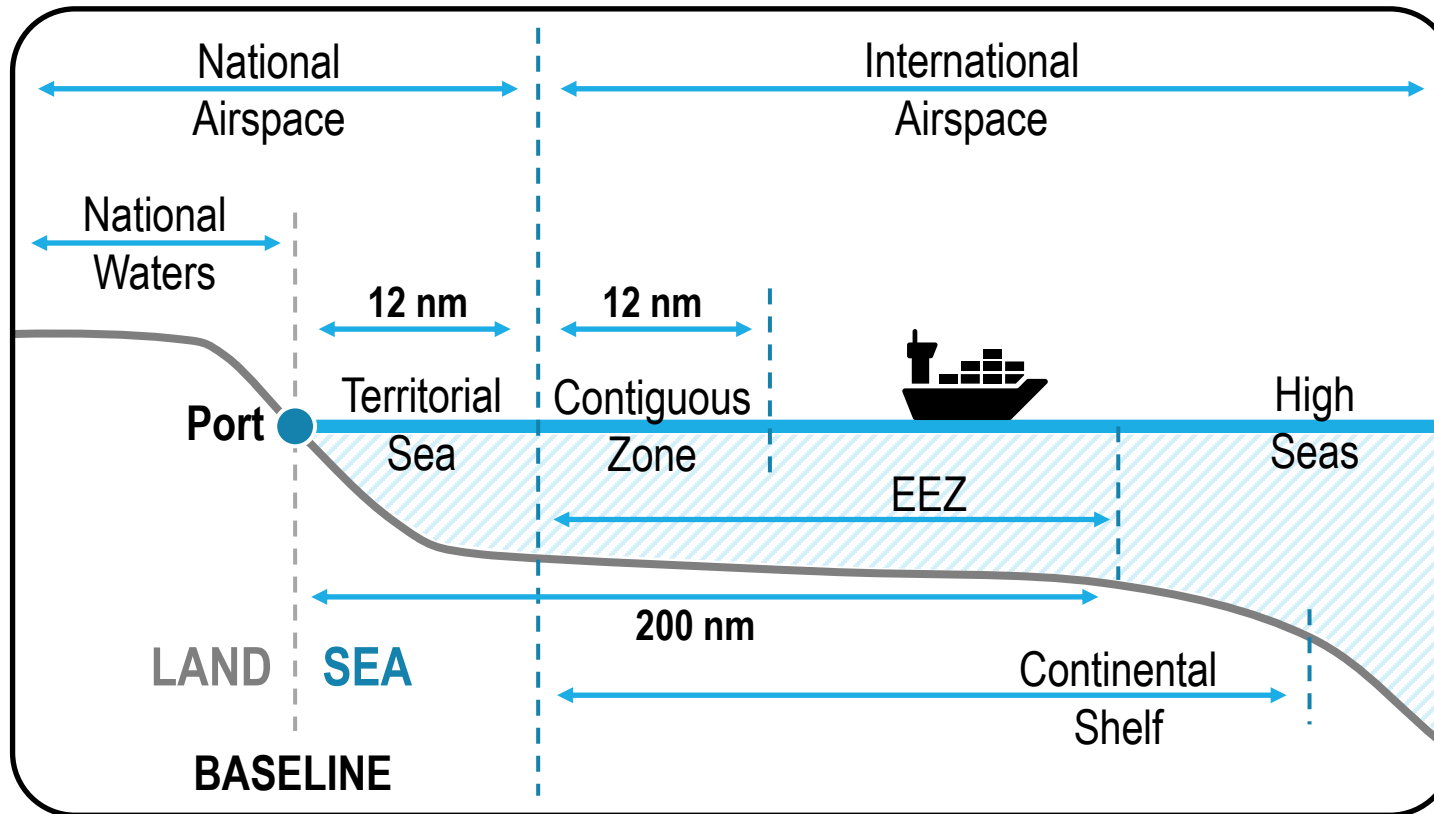
Port Systems

- *A port system can be defined as a system of two or more ports located in proximity within a given area. It can relate to a complete coastline, such as the West Coast of North America.*

Maritime Zones and Legal Boundaries



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Sovereign Waters

- Territorial waters
 - 12 nautical miles out to the coastline towards the high seas.
 - Regarded as the sovereign territory of the state.
 - Exclusive rights for all the natural resources.
 - Includes air space.
- Archipelagic waters
 - Territorial waters within islands of an archipelago.
 - Sovereignty
 - Archipelagic states can designate sea lanes through these waters (e.g. Strait of Malacca).

Sea Jurisdiction of Indonesia

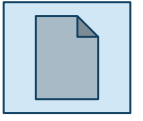


- Archipelagic & territorial waters of Indonesia
- Claimed exclusive economic zone of Indonesia

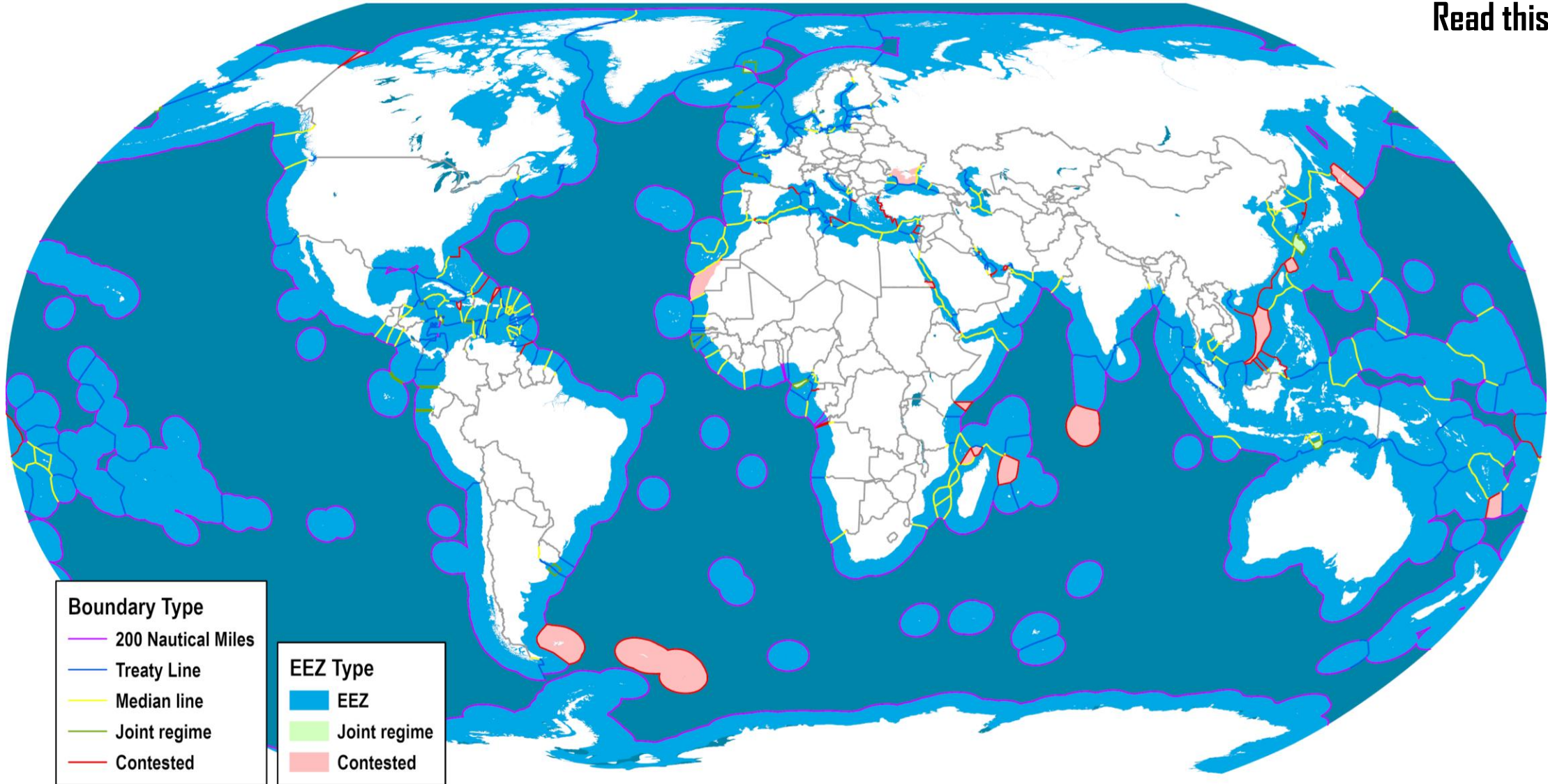
Areas outside of sovereignty but within national jurisdiction

- Contiguous zone
 - 12-nautical mile area extending beyond the territorial sea.
 - Prevent any potential infringement of its laws and regulations.
- Exclusive economic zone (EEZ)
 - Sea zone over which a state has rights to the exploration and use of marine resources:
 - Fishing.
 - Oil and mineral extraction.
 - 200 nautical miles (370 km) out from its coast.
 - Cannot prevent free navigation.
- Continental shelf
 - Area, often extending beyond the EEZ, with relatively shallow waters.
 - A state has the right over seabed resources.

Exclusive Economic Zones



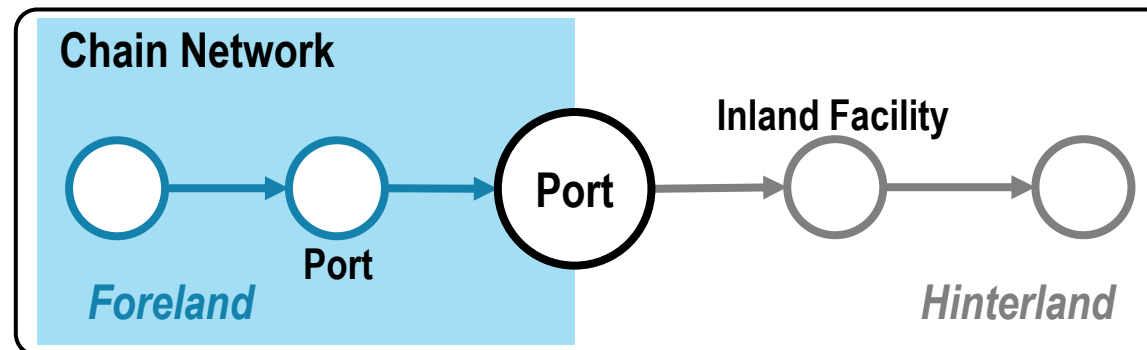
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Port Networks

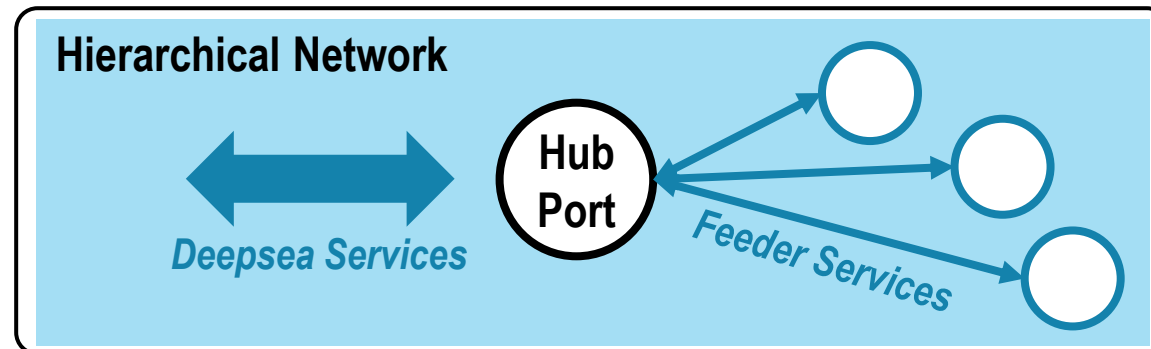
- Chain networks

- Ports are nodes part of a sequence of flows where the output of one node in the network is the input for another.
- Trade segments, such as bulk, have simple chain networks composed of two port nodes; one for loading and the other for unloading.
- Container ports
 - Deepsea service chains.
 - Container ports and inland load centers.



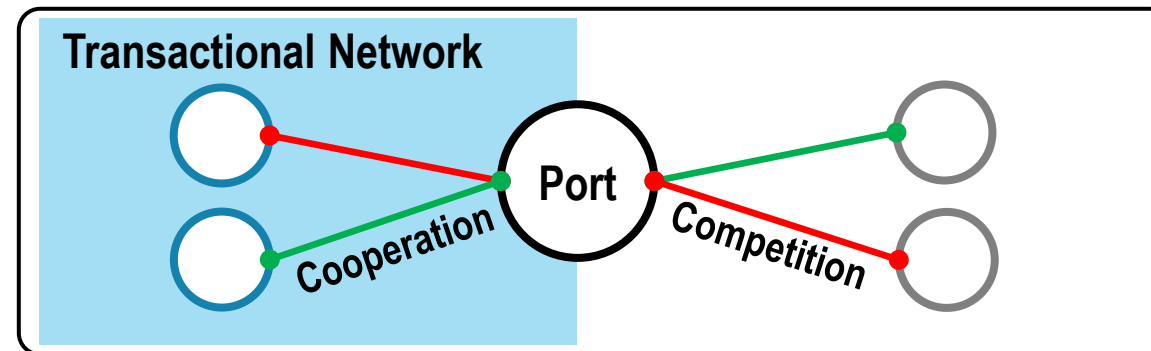
Port Networks

- Hierarchical networks
 - Ports are nodes part of different connectivity levels.
 - Some locations can be reached indirectly as opposed to directly.
 - Hub-feeder port relations in container shipping.



Port Networks

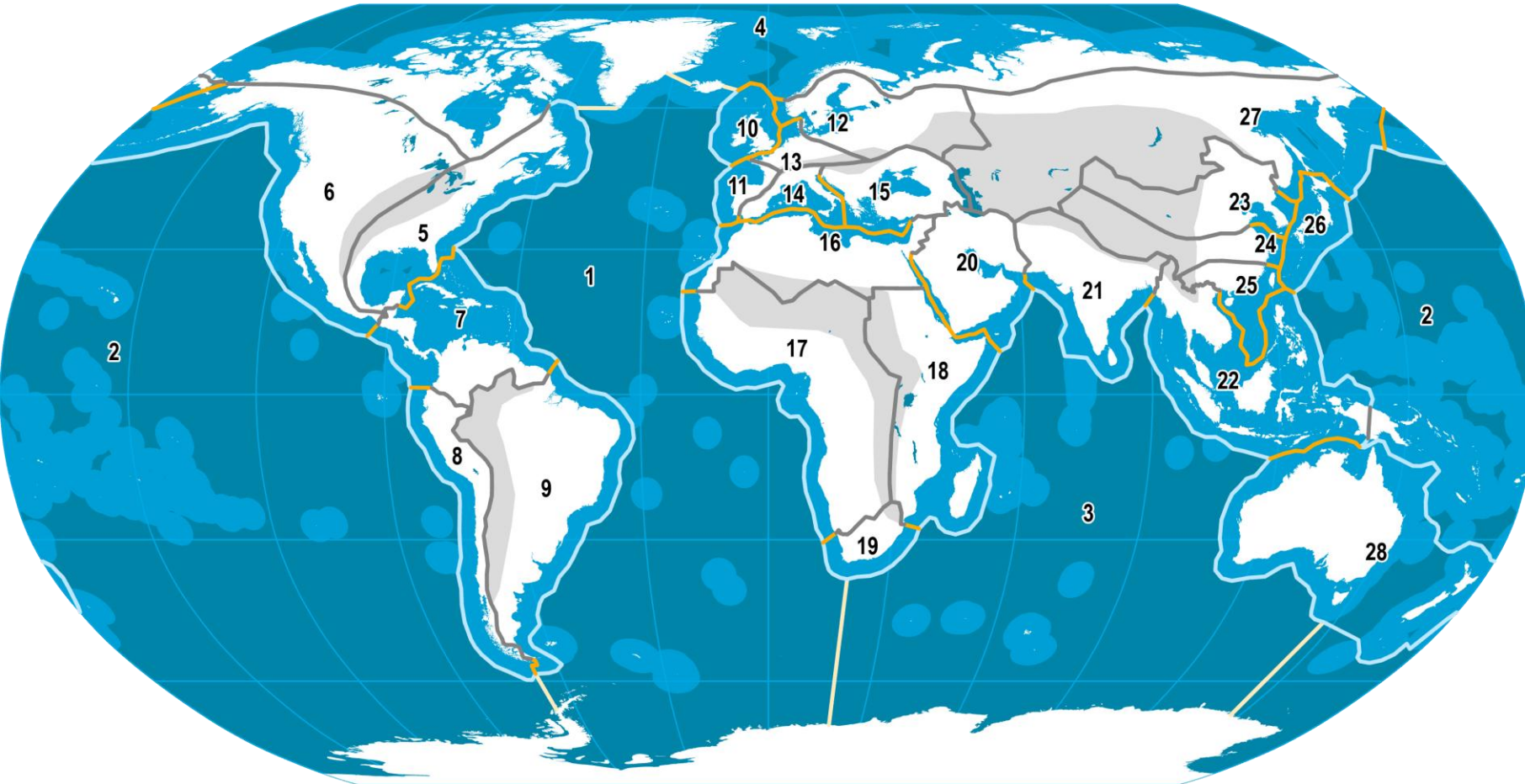
- Transactional networks
 - Ports are nodes in a system of commercial relations.
 - Can be competitive or complementary.
 - Compete to attract traffic, which can be a zero-sum game where the traffic handled at one port is at the expense of another.
 - Can complement other ports, particularly when they are part of the same transport chain.
 - Use advantages such as location, cost, and productivity to attract or retain shipping services and traffic.



Port Range

- *A port range can be defined as a group of ports situated along the same seashore and potentially sharing access to a hinterland.*
- *A multi-port gateway region refers to a group of ports in proximity competing for the same port calls and hinterland. It has a smaller geographical scale than a container port range. The locational relationship to nearby identical traffic hinterlands is one of the criteria that can be used to group adjacent ports into the same multi-port gateway region. The port-calling patterns in the maritime service networks and hinterland connectivity profile can also help group ports into a multi-port gateway region.*

Major Maritime Ranges



Main Maritime Ranges

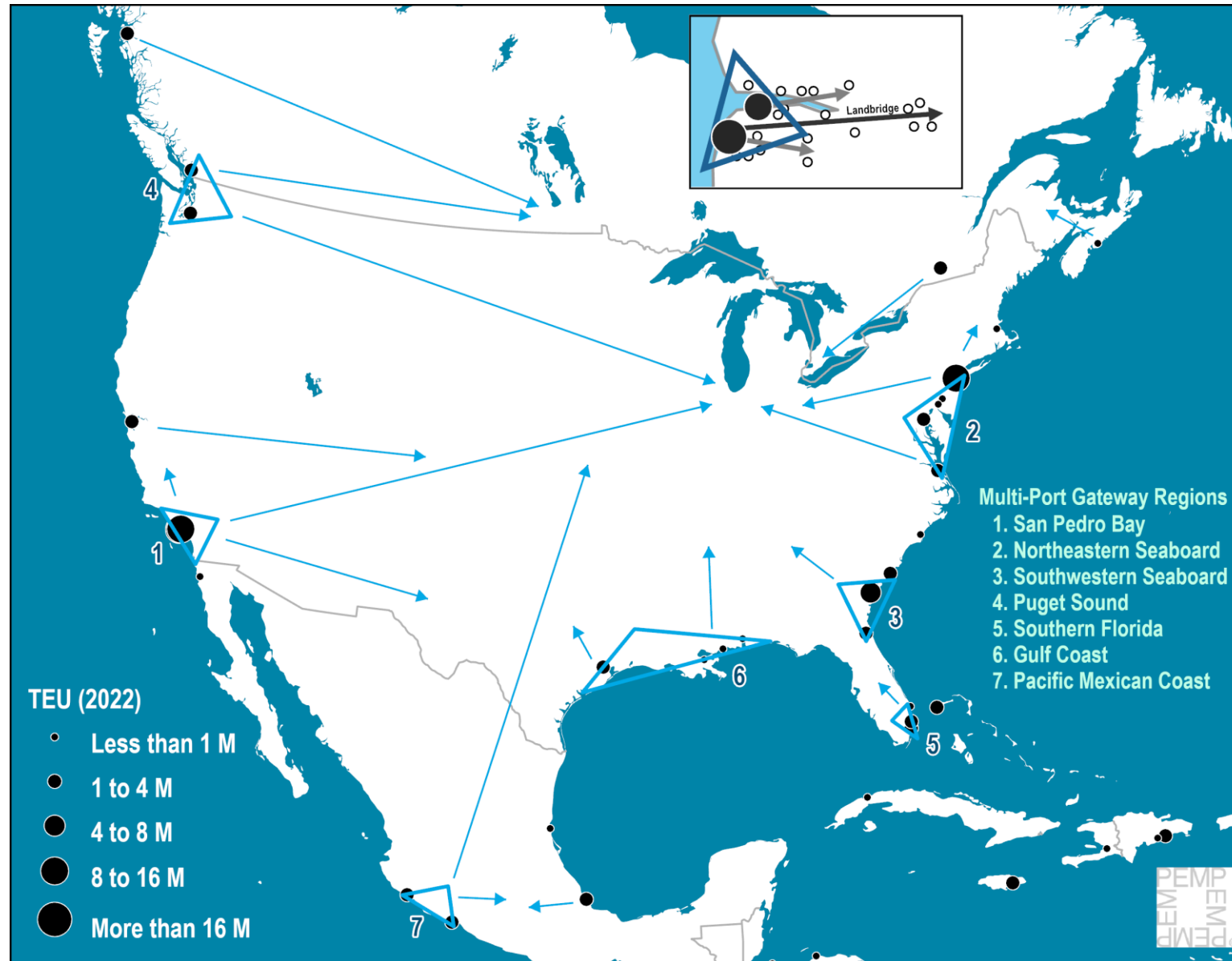
- | | |
|------------------------------|-----------------------------|
| 1. Atlantic | 18. East African Coast |
| 2. Pacific | 19. South Africa |
| 3. Indian | 20. Middle East |
| 4. Arctic | 21. South Asia |
| 5. North American East Coast | 22. Southeast Asia |
| 6. North American West Coast | 23. Yellow Sea |
| 7. Caribbean Basin | 24. Central China |
| 8. South American West Coast | 25. Southern China / Taiwan |
| 9. South American East Coast | 26. Japan |
| 10. British Isles | 27. Russian Far East |
| 11. Atlantic Europe | 28. Oceania |
| 12. Baltic | |
| 13. Northern Europe | |
| 14. West Mediterranean | |
| 15. East Mediterranean | |
| 16. South Mediterranean | |
| 17. West African Coast | |

-  Oceanic Boundary
-  Maritime Boundary
-  Inter-Range Boundary
-  Hinterland Boundary
-  Exclusive Economic Zone
-  Contestable Hinterland



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The North-American Container Port System and its Multi-Port Gateway Regions



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