Cambiamenti climatici e città costiere: implicazioni globali dello scioglimento dei ghiacci e dell'innalzamento del livello del mare

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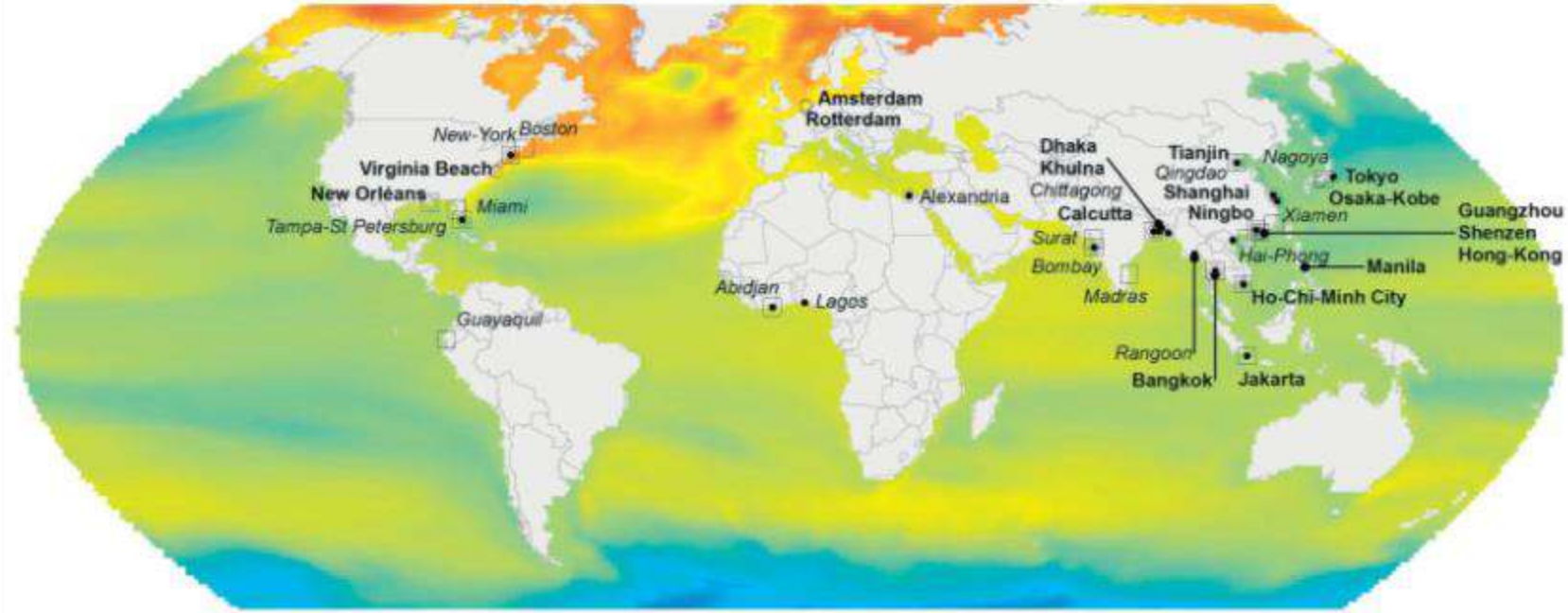
Joint Technical Research Unit on Intelligence, Defense and Recovery in Architecture

DIPARTIMENTO DI STORIA
DISEGNO E RESTAURO
DELL'ARCHITETTURA

SAPIENZA
UNIVERSITÀ DI ROMA

Future sea level rise and a review of vulnerable coastal cities



Selection of most vulnerable coastal cities to future marine flooding

- 20 cities with population most exposed to coastal flooding in the 2070s assuming 0.5m sea level rise (Hanson et al., 2011)
- 20 cities with assets most exposed to coastal flooding in the 2070s assuming 0.5m sea level rise (Hanson et al., 2011)
- 20 cities with the highest economic average annual losses due tomarine flooding in the 2050's, assuming that coastal management maintains a constant probability of flooding and optimistic sea level rise scenario (Hallegatte et al., 2013)

Vertical ground motions affecting vulnerable coastal cities

Manilla	Evidences of significant subsidence in substancial parts of the city
Alexandria	Evidences that urban-subsidence has not significantly exacerbated coastal risks in recent decades
New-York	No information found on recent urban subsidence

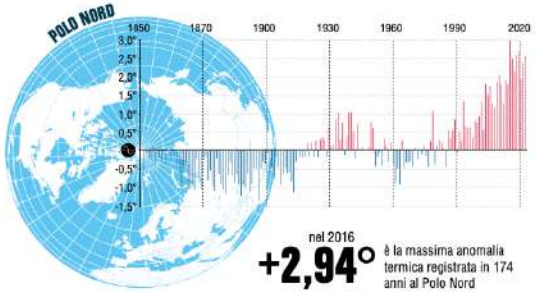
Projection map in sea level regional variability due to steric effects

+0.3 m
0 m
- 0.3 m

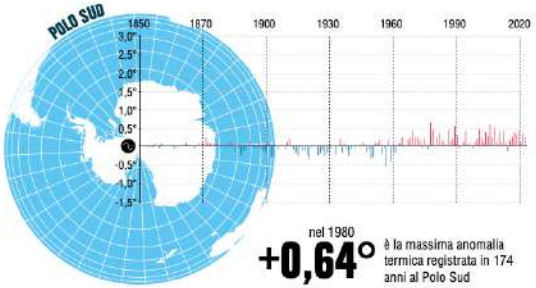
Figure 7. Projection map in sea level regional variability due to steric effects (differences between the 2080–2100 and 1980–2000 periods, with the global mean difference removed; output of the CNRM-CM5 run rcp8.5 r1i1p1 climate model [*Voldoire et al.*, 2013]) on which are superimposed sites of most vulnerable coastal cities [*Hanson et al.*, 2011; *Hallegatte et al.*, 2013]. This map highlights that by the end of the 21st century, many vulnerable cities are located along the eastern coast of the USA and in southeast Asia. There is evidence of ground subsidence in some areas of several of these cities but systematic measurements by precise positioning techniques are lacking. Coastal cities are selected according to two global assessments of flood risk in world coastal cities [*Hanson et al.*, 2011; *Hallegatte et al.*, 2013]. Information on ground motions is available in the following studies: *Nicholls* [2011]; *Wang et al.* [2012a, 2012b]; *Hu et al.* [2004]; *Chatterjee et al.* [2007]; *Dixon et al.* [2006]; *Chen et al.* [2010]; *Cuenca et al.* [2007]; *Wöppelmann et al.* [2013]; *Chaussard et al.* [2013]; Ho-Tong-Minh-Din (personal communication).

da Cazenave, Le Cozannet 2014

Anomalie termiche ai due poli | 1850-2023



nel 2016 **+2,94°** è la massima anomalia termica registrata in 174 anni al Polo Nord



nel 1980 **+0,64°** è la massima anomalia termica registrata in 174 anni al Polo Sud

Vulnerabilità al calore

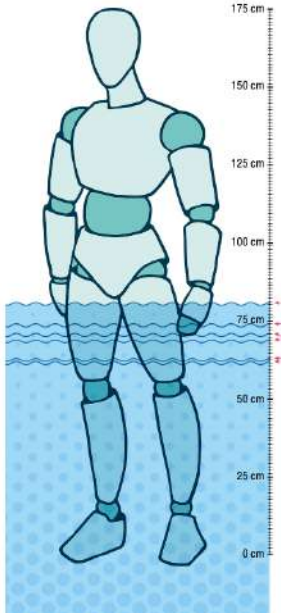
L'indice di vulnerabilità al calore considera:
- la percentuale di popolazione sopra i 65 anni;
- le malattie croniche respiratorie, cardiovascolari e diabete;
- la percentuale di popolazione urbana.

Un valore più alto indica una maggiore vulnerabilità del Paese.

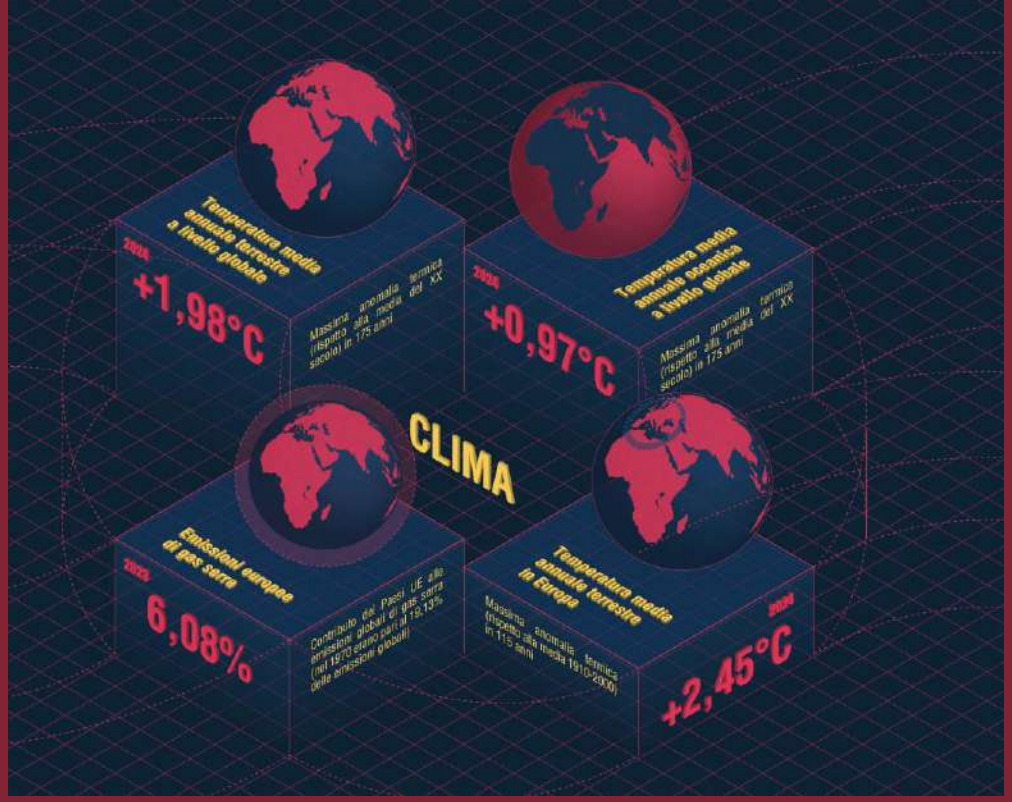
0 25 50 75 100

	1990	2019	
Albania	25,8	34,1	
Bosnia Erzegovina	29,6	37,2	
Bulgaria	36,3	40,1	
Croazia	34,8	38	
Estonia	43,8	43,9	
Lettonia	34,5	37,1	
Lituania	35,8	36,2	
Macedonia del Nord	36,3	38	
Montenegro	36,8	38,5	Europa centrale e orientale
Polonia	37,4	38,8	34,7 38,0
Repubblica Ceca	38,8	43,2	
Serbia	33,2	34,3	
Slovacchia	32,4	34,2	
Slovenia	34,4	38,8	
Ungheria	37,4	42,2	
Danimarca	35,3	38,6	
Finlandia	38,5	42,8	Europa settentrionale
Islanda	41,7	42,3	42,1 43,3
Norvegia	42,3	43,2	
Svezia	44,2	44,3	
Cipro	38,5	39,6	
Grecia	38,2	41,8	Europa meridionale
Italia	41,2	41,6	39,4 41,8
Portogallo	35,8	40	
Spagna	40,6	41,5	
Turchia	34,8	42,8	
Austria	37,3	38,1	
Belgio	44,7	45,3	Europa occidentale
Francia	38,9	38,8	40,1 41,8
Germania	41,8	42,7	
Irlanda	37,8	38,4	
Lussemburgo	41,1	45,5	
Paesi Bassi	38,8	44,8	

Previsione di crescita del livello del mare | 2100



	2040	2060	2080	2100
Alessandria d'Egitto	19 cm	34 cm	52 cm	74 cm
Dubrovnik	14 cm	27 cm	42 cm	62 cm
Iraklion	21 cm	38 cm	58 cm	81 cm
Marsiglia	15 cm	27 cm	43 cm	63 cm
Valencia	18 cm	32 cm	49 cm	71 cm
Venezia	17 cm	31 cm	48 cm	69 cm



da Rapporto DIS 2024

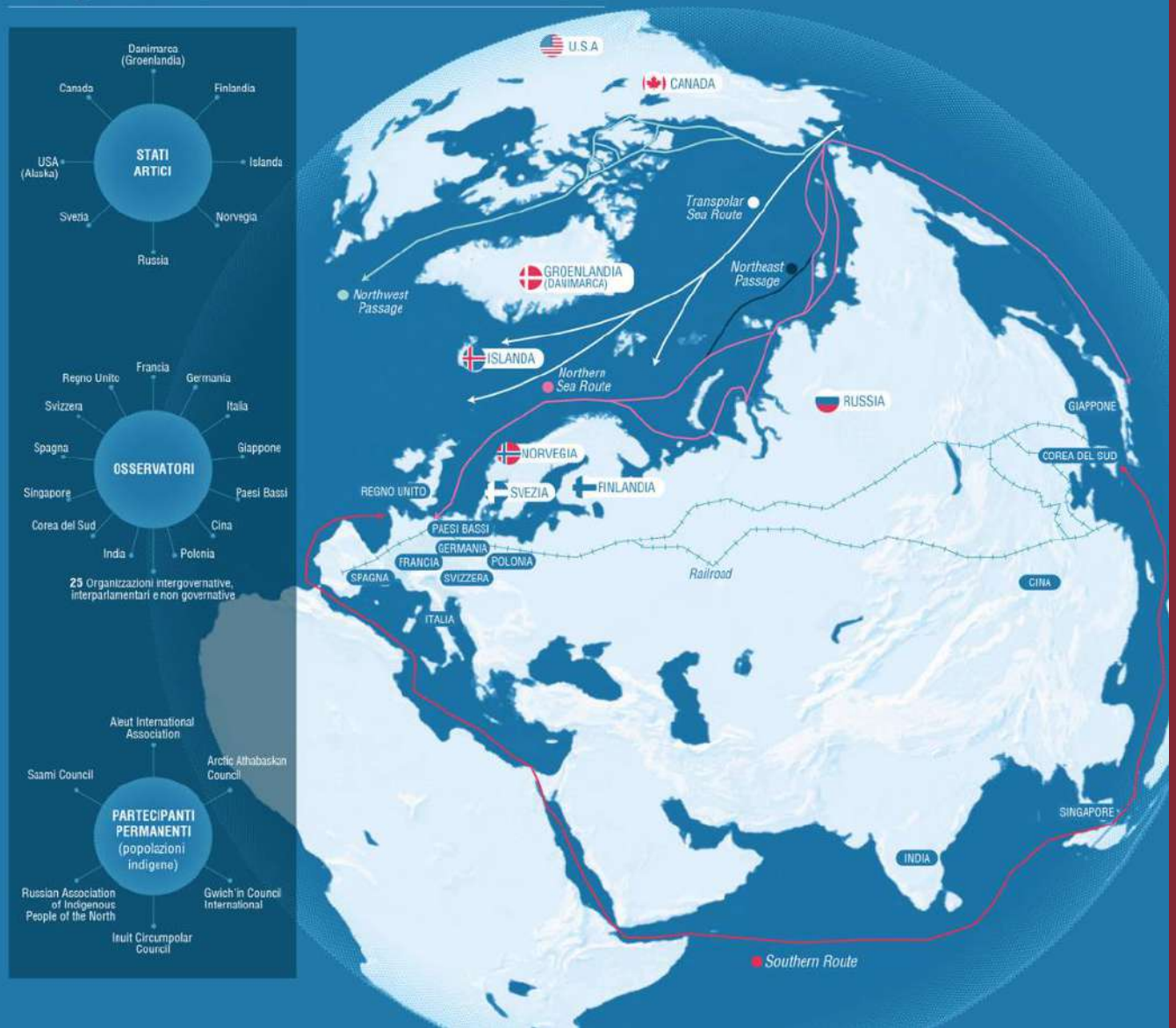
CHAPTER 1 – BECAUSE OF THE ICE COURTAIN

Svalbard's ground station, SvalSat, downloads time-sensitive data from most of the world's commercial and scientific satellites, but not from military missions, its operator says. Source: Kongsberg Satellite Services

La nuova geopolitica del Mar Artico

Il 2023 ha confermato la centralità dell'Artico quale fronte di crescente rilevanza strategica e geopolitica. Gli effetti del cambiamento climatico e le conseguenti dinamiche economiche e securitarie hanno innalzato il livello di priorità dell'area sia per i Paesi rivieraschi che per altri attori internazionali.

Consiglio Artico | istituito a seguito della Dichiarazione di Ottawa (1996)



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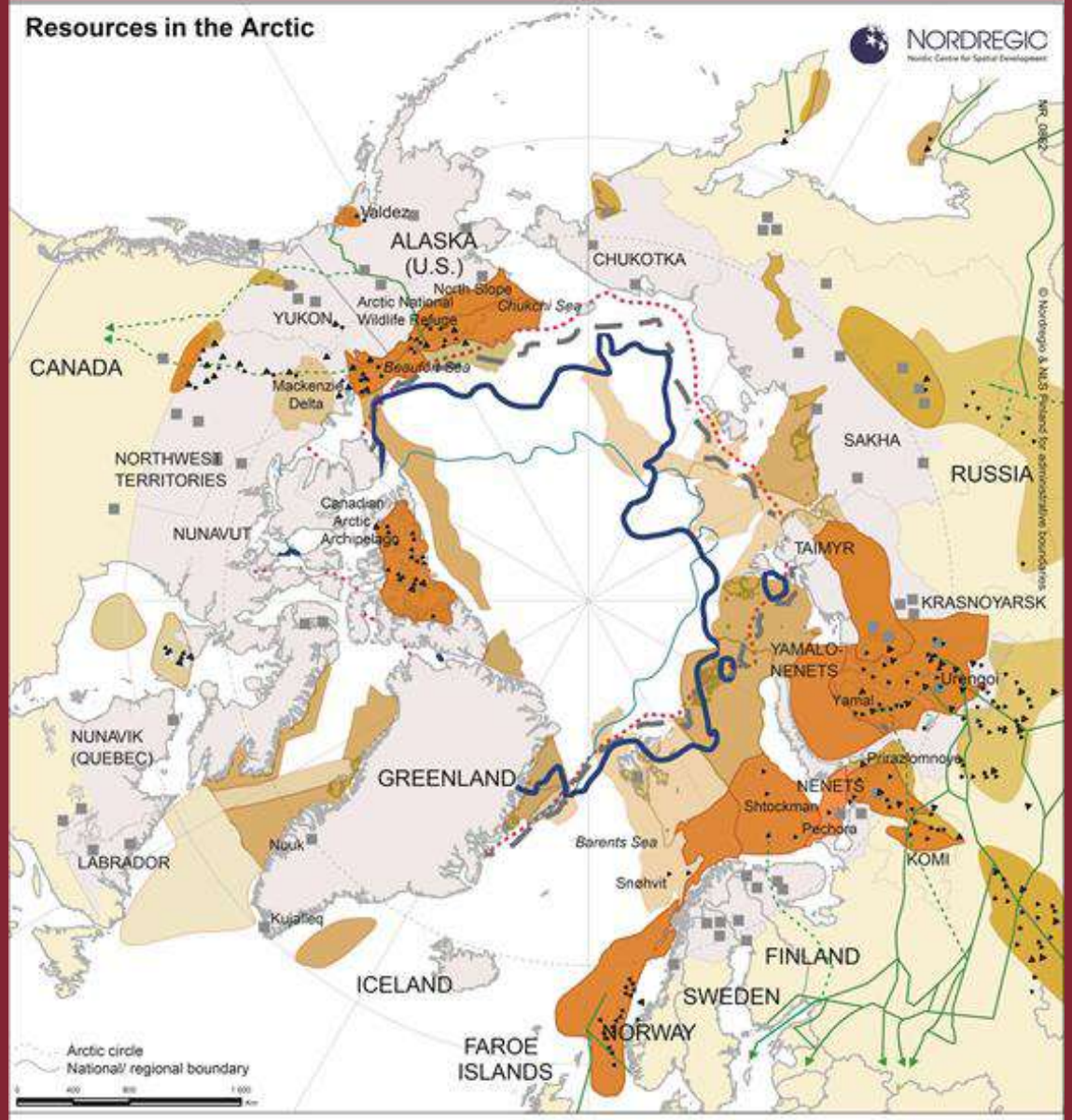


Oil & gas in the Arctic

- Gas/oil: prospective areas & reserves
- Gas/ oil exploration and production
- Main mining sites
- Main existing gas/oil pipeline
- Main projected gas/oil pipeline

Potential oil and/or gas field (Probability that at least one accumulation over 50 million barrels of oil or oil-equivalent gas exist after USGS)

- High (above 50%)
- Medium (30 - 50%)

- Sea ice extent in September 2012*
- Sea ice extent in September 2014
- Average sea ice extent for September in 1979 - 2000
- Average sea ice extent for September in 1980 - 2010

Arctic region defined as in Arctic Human Development Report

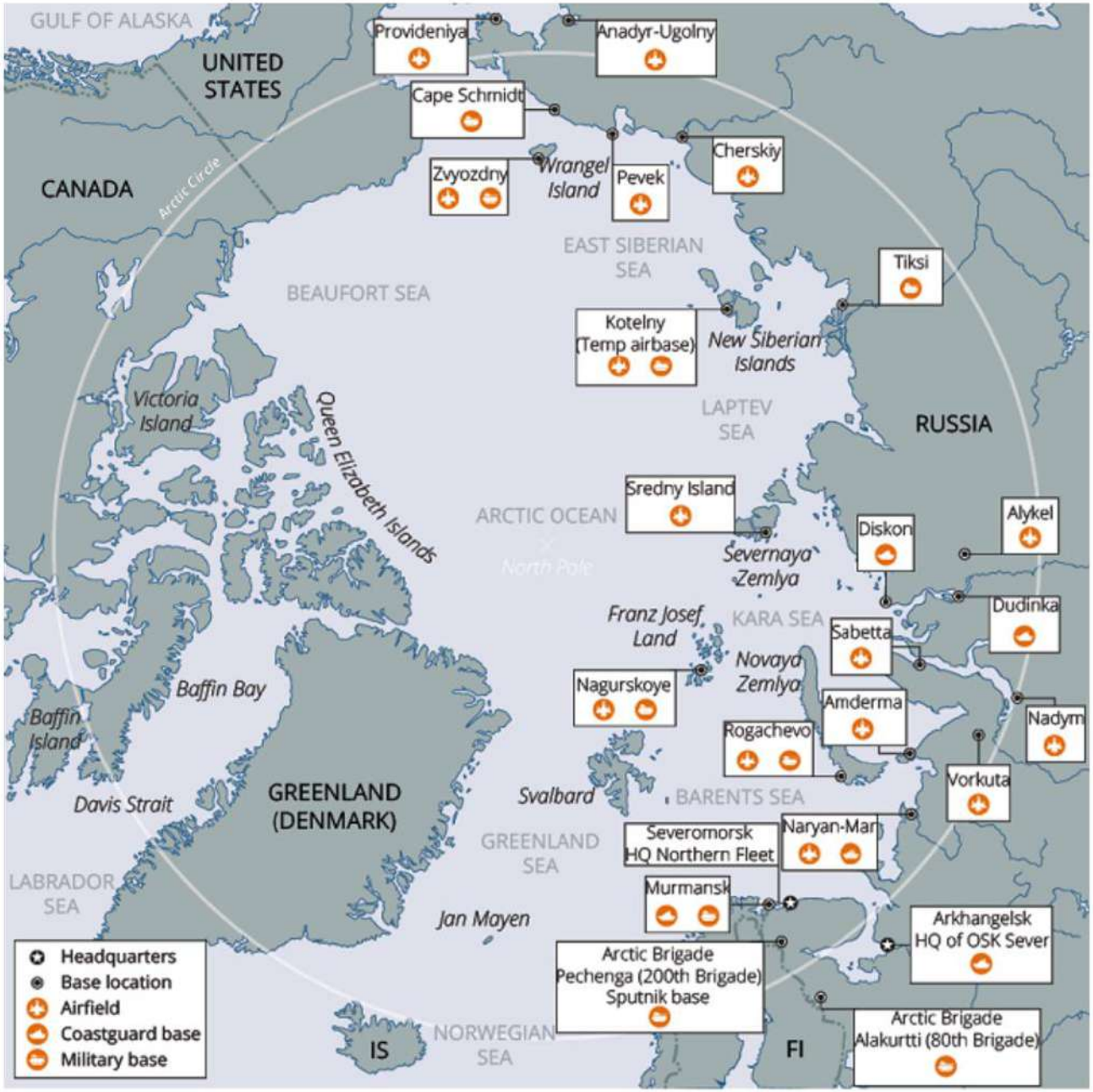
Data source: Grid-Arendal, ACIA, AMAP, Gaz de France, East European Gas Analysis, NSIDC, United States Geological Survey, University of Lapland, Nordregio

*) Minimum sea ice extent was measured in September 2012 (of available data 1979-2014)

Presenza e interessi russi nell'Artico

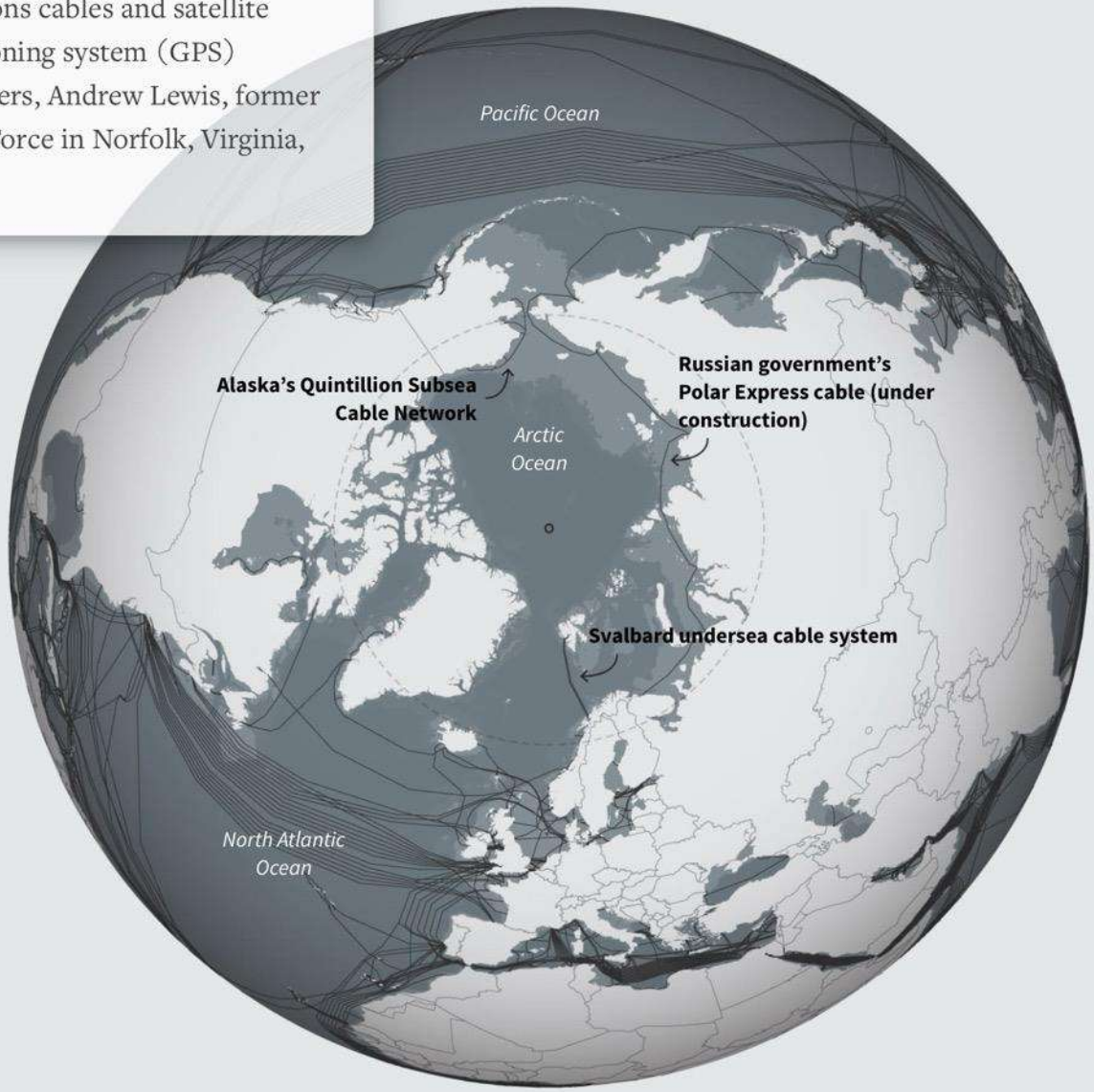
da Rapporto DIS 2023

Figure 2: Russian Arctic military infrastructure



Source: Mathieu Boulègue, *Russia's Military Posture in the Arctic: Managing Hard Power in a 'Low Tension' Environment, Chatham House*: https://www.chathamhouse.org/sites/default/files/2019-06-28-Russia-Military-Arctic_0.pdf [accessed 1 November 2023]

Also at risk today are communications cables and satellite systems including the global positioning system (GPS) linking both civilian and military users, Andrew Lewis, former commander of NATO's Joint Task Force in Norfolk, Virginia, told Reuters.



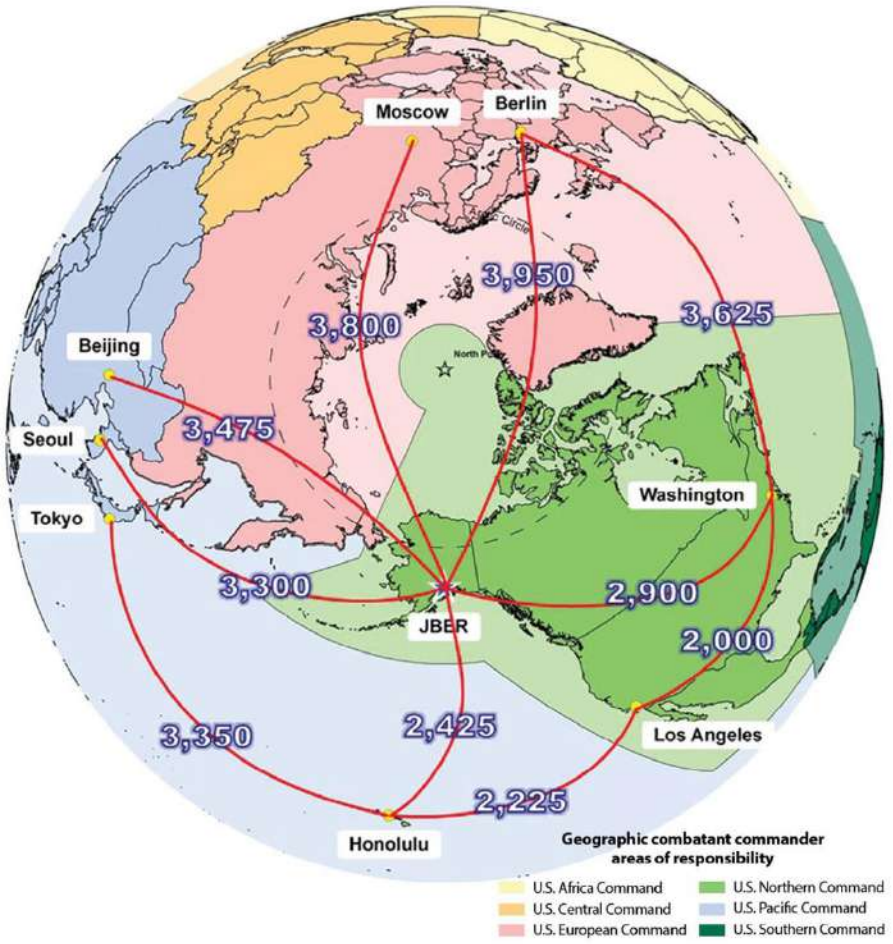
da Gronholt-Pedersen, Fouche 2022

A ground-based interceptor missile is emplaced in July 2006 at the Missile Defense Complex, Fort Greely, Alaska. Alaska's location makes the state a critical component of the nation's ballistic missile defense system. (Photo courtesy of the U.S. Army)

Why Alaska and the Arctic are Critical to the National Security of the United States

Col. Michael J. Forsyth, U.S. Army

Over the past five years, Russia has moved aggressively to build its Arctic military capabilities, apparently in an effort to secure its claims and interests in the region.[1] Increasingly, human activity is occurring in the Arctic as the sea ice recedes and economic opportunity opens to nations via new shipping



(Graphic courtesy of North American Aerospace Defense Command [NORAD]; used in an Alaskan Command and Alaska NORAD Region command briefing. Alaska is close to the center of the hemisphere and Joint Base Elmendorf-Richardson [JBER] is uniquely positioned to project power. The distances depicted in nautical miles are to select world capitals from JBER.)

Figure 1. The Northern Hemisphere from the Perspective of the North Pole

Department of the Air Force Equities in the Arctic

ALASKA

- **JOINT BASE ELMENDORF-RICHARDSON (JBER):** F-22, E-3, C-17, C-130, C-12F, Alaska Rescue Coordination Center: HC-130, HH-60
- **EIELSON AFB:** F-35, F-16, ANG KC-135, Polar Survival School
- **JOINT PACIFIC ALASKA RANGE COMPLEX (JPARC):** Airspace & Training Grounds
- **CLEAR AFS:** Ballistic Missile Early Warning, Space Domain Awareness
- **POINT BARROW/NORTH SLOPE:** Alaska Radar System (15 radars, 3 part of North Warning System)
- **EARECKSON AS:** Missile Defense Radar

DAF is responsible for 79% of DoD Arctic Resourcing

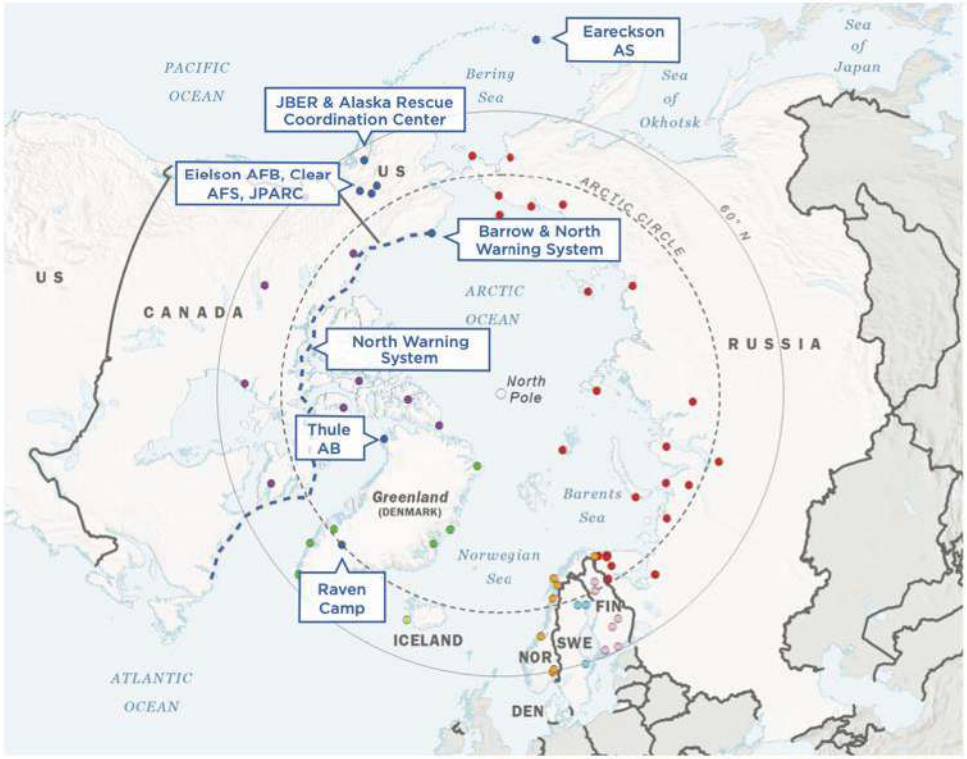
Source: 2016 DoD Report to Congress

CANADA

- **NORAD:** North Warning System (~50 radars)

GREENLAND

- **THULE AB:** Ballistic Missile Early Warning, Space Domain Awareness
- **RAVEN CAMP:** ANG Training for LC-130



Map Source: National Geospatial-Intelligence Agency

SAMPLE OF ARCTIC REGION MILITARY FACILITIES

UNITED STATES · NORWAY · FINLAND · CANADA · SWEDEN · DENMARK/GREENLAND · RUSSIA · ICELAND

da *The Department of the Air Force - Arctic Strategy* 2022

Aerial view of Isfjord Radio, Svalbard, Norway.

Cutting diesel use in Arctic towns

TESTING OUT THE POWER OF SOLAR ENERGY IN SVALBARD, NORWAY

By testing and proving hybrid solutions at Isfjord Radio and elsewhere on Svalbard, and making these a "best practice" for Arctic energy transition, Store Norske Energi hopes to accelerate the introduction of renewable energy in other Arctic communities.

Photo credit: Store Norske

The three paths of the Chinese BRI

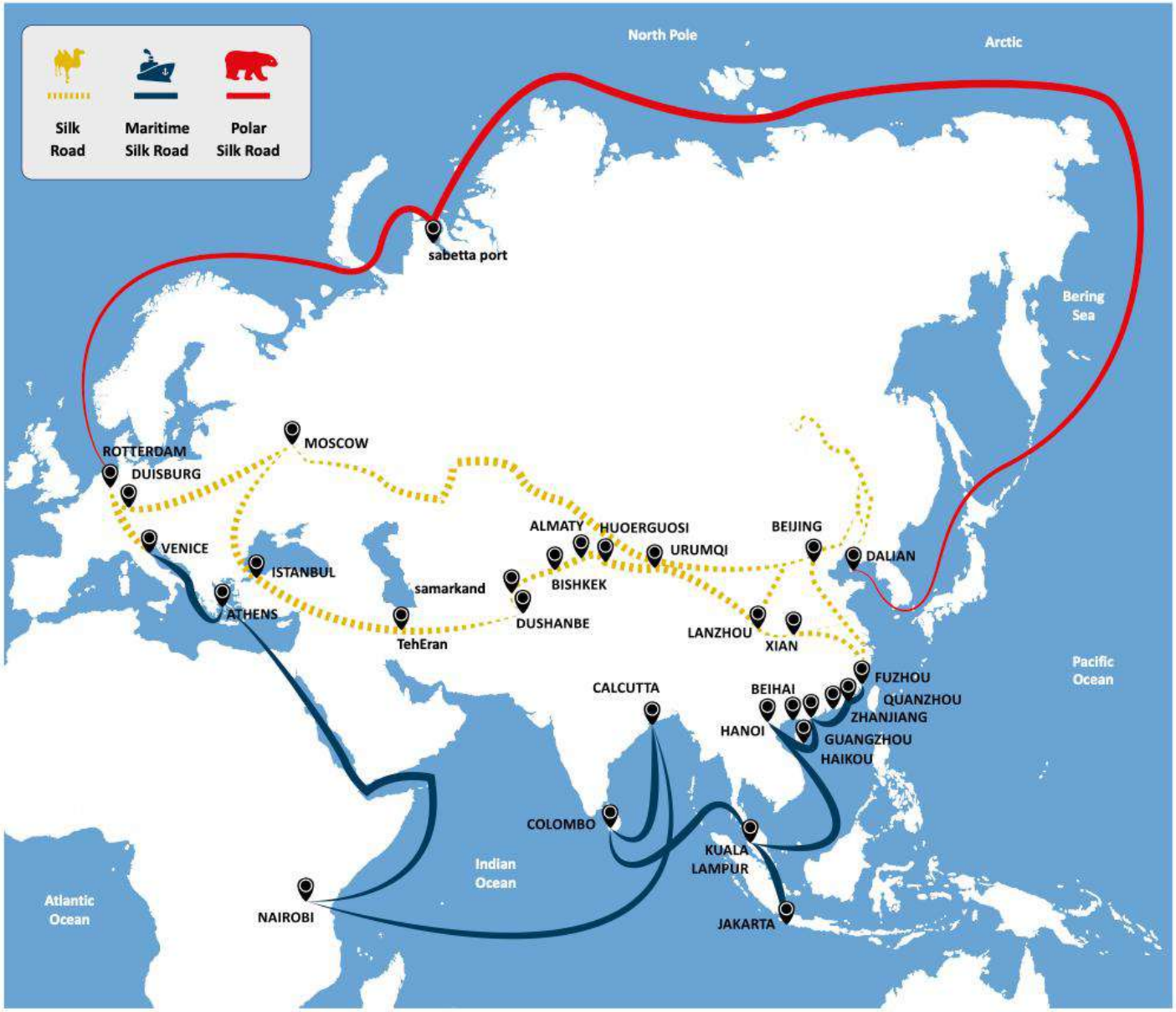
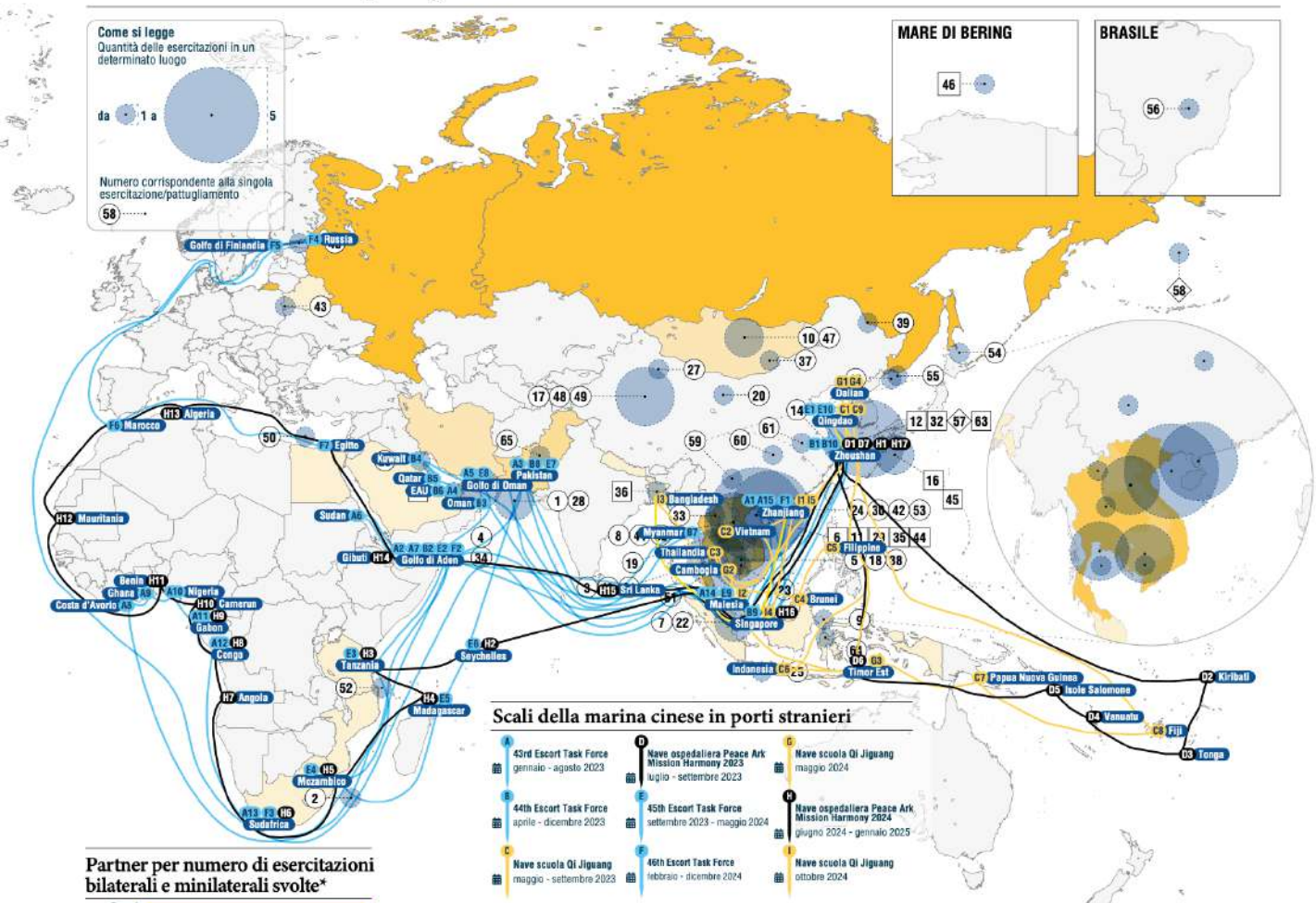


Figure 8 - Source: SRM on China's Development and Reform Commission, The Arctic Institute, National Snow and Ice data Centre, Reuters

da Intesa San Paolo 2022

Esercitazioni militari e pattugliamenti svolti dalla Cina con Paesi stranieri nel 2023 e nel 2024



Scali della marina cinese in porti stranieri

A 43rd Escort Task Force — gennaio - agosto 2023

B 44th Escort Task Force — aprile - dicembre 2023

C Nave scuola Qi Jiguang — maggio - settembre 2023

D Nave ospedaliera Peace Ark Mission Harmony 2023 — luglio - settembre 2023

E 45th Escort Task Force — settembre 2023 - maggio 2024

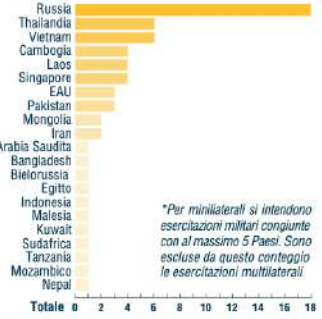
F 46th Escort Task Force — febbraio - dicembre 2024

G Nave scuola Qi Jiguang — maggio 2024

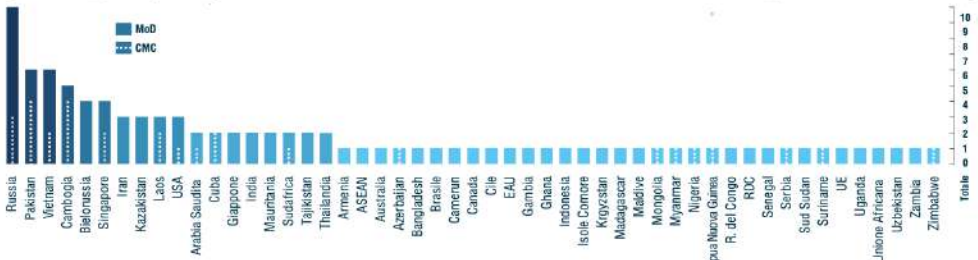
H Nave ospedaliera Peace Ark Mission Harmony 2024 — giugno 2024 - gennaio 2025

I Nave scuola Qi Jiguang — ottobre 2024

Partner per numero di esercitazioni bilaterali e minilaterali svolte*



Colloqui con il Ministro della Difesa (MoD) cinese e/o un Vicepresidente della Commissione Militare Centrale (CMC)



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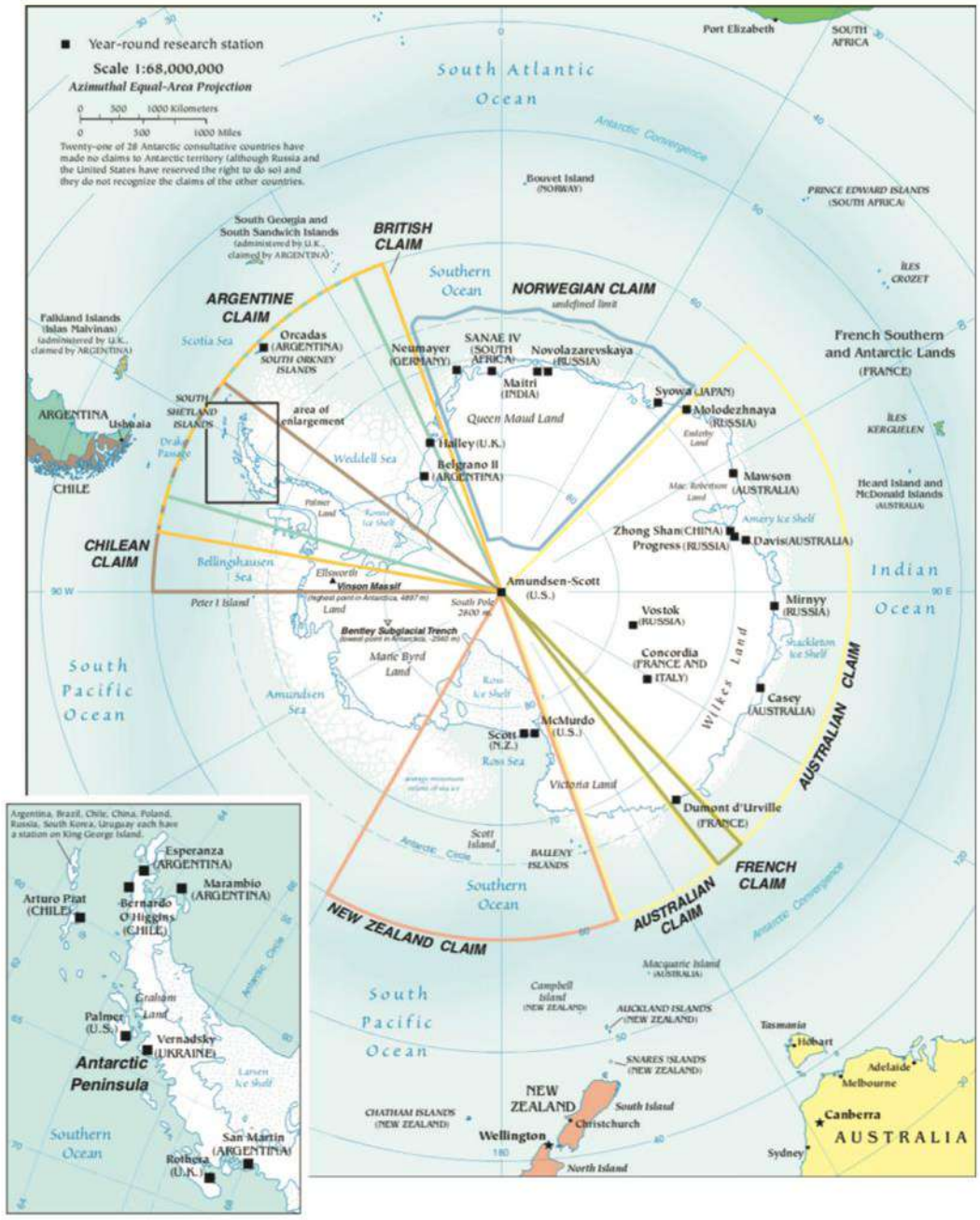
Current Antarctic Territorial Claims



SOURCE: Reproduced from Central Intelligence Agency, *The World Factbook*, undated.

da *China Antarctica* 2021

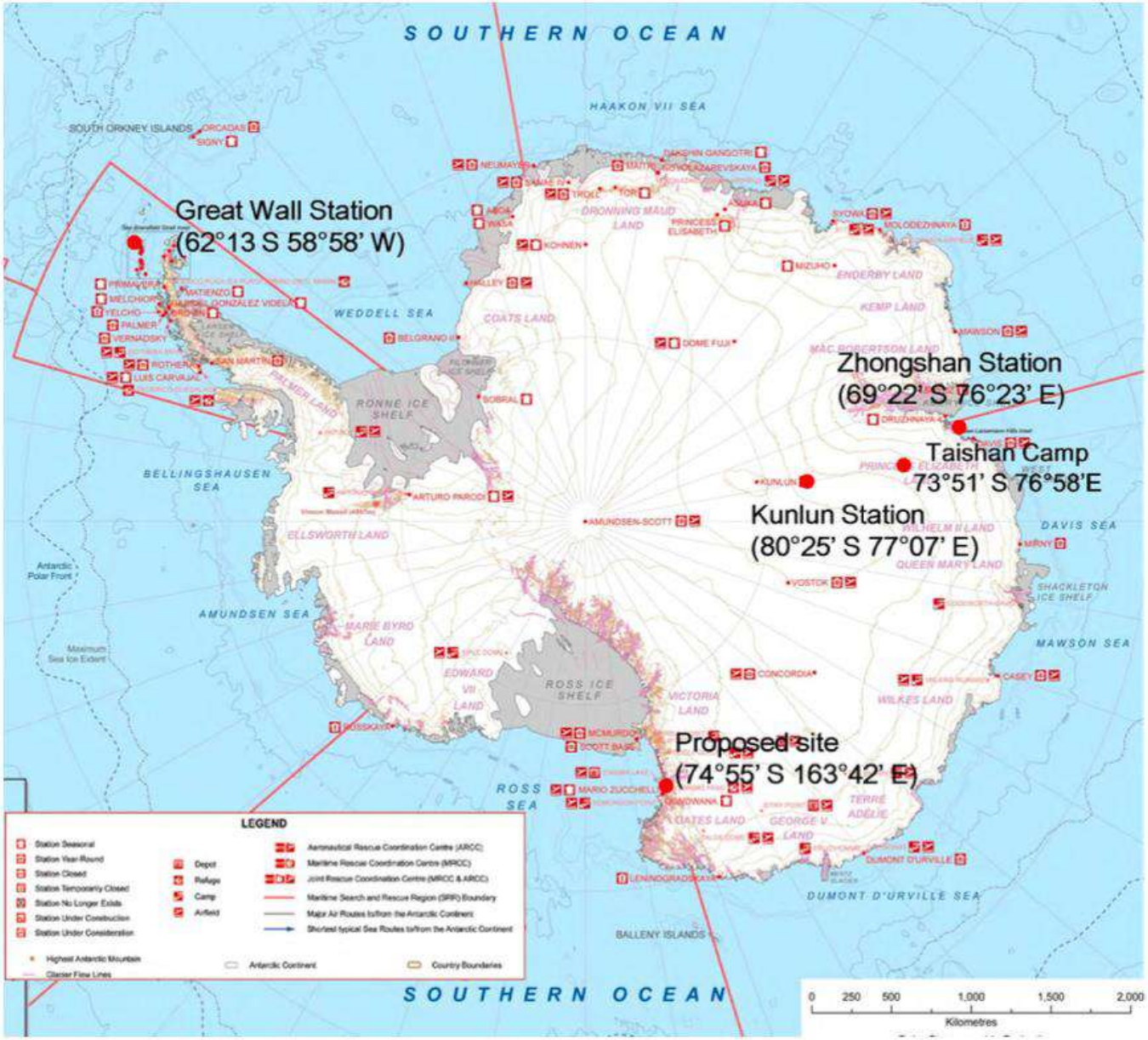
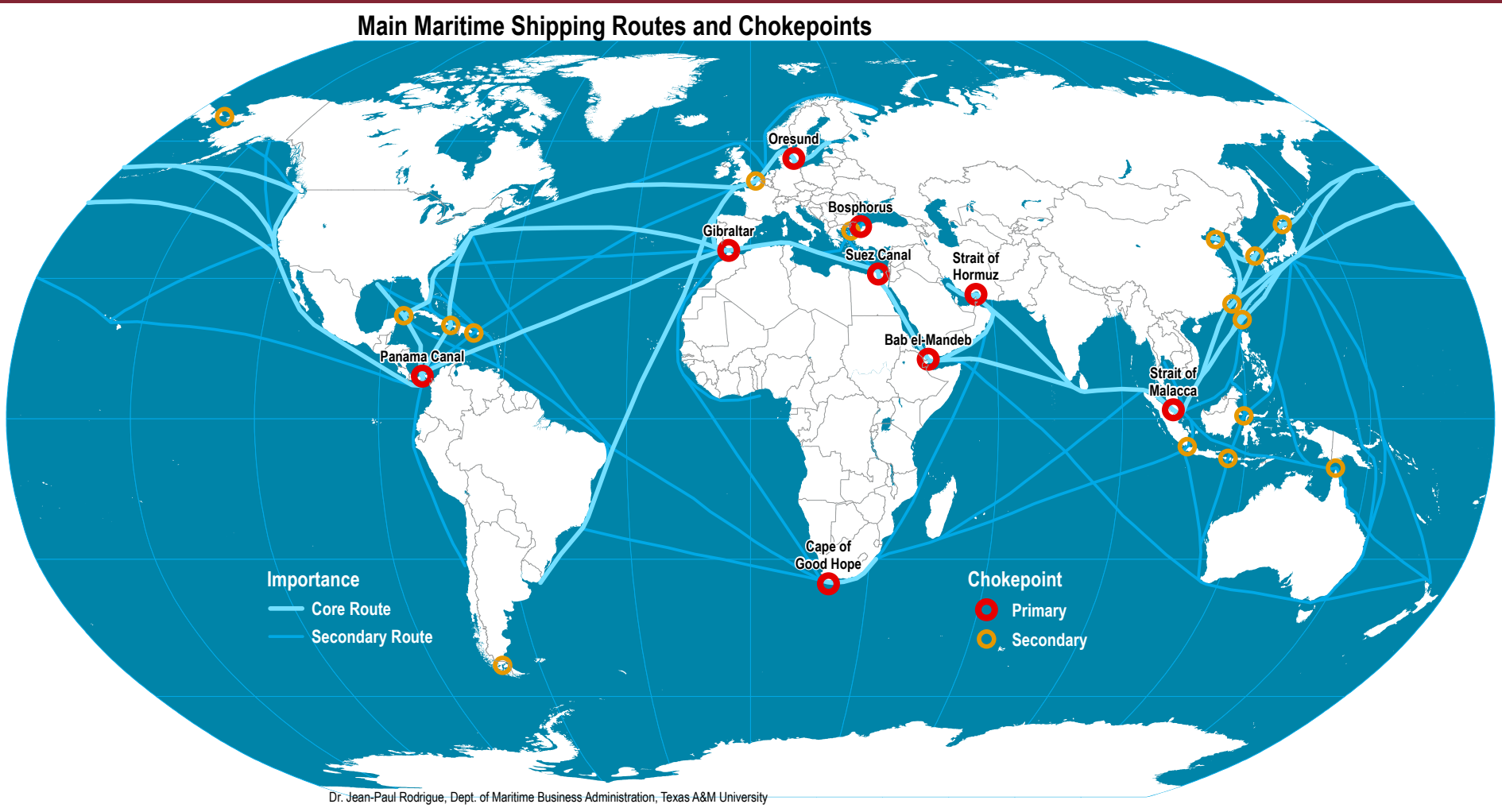
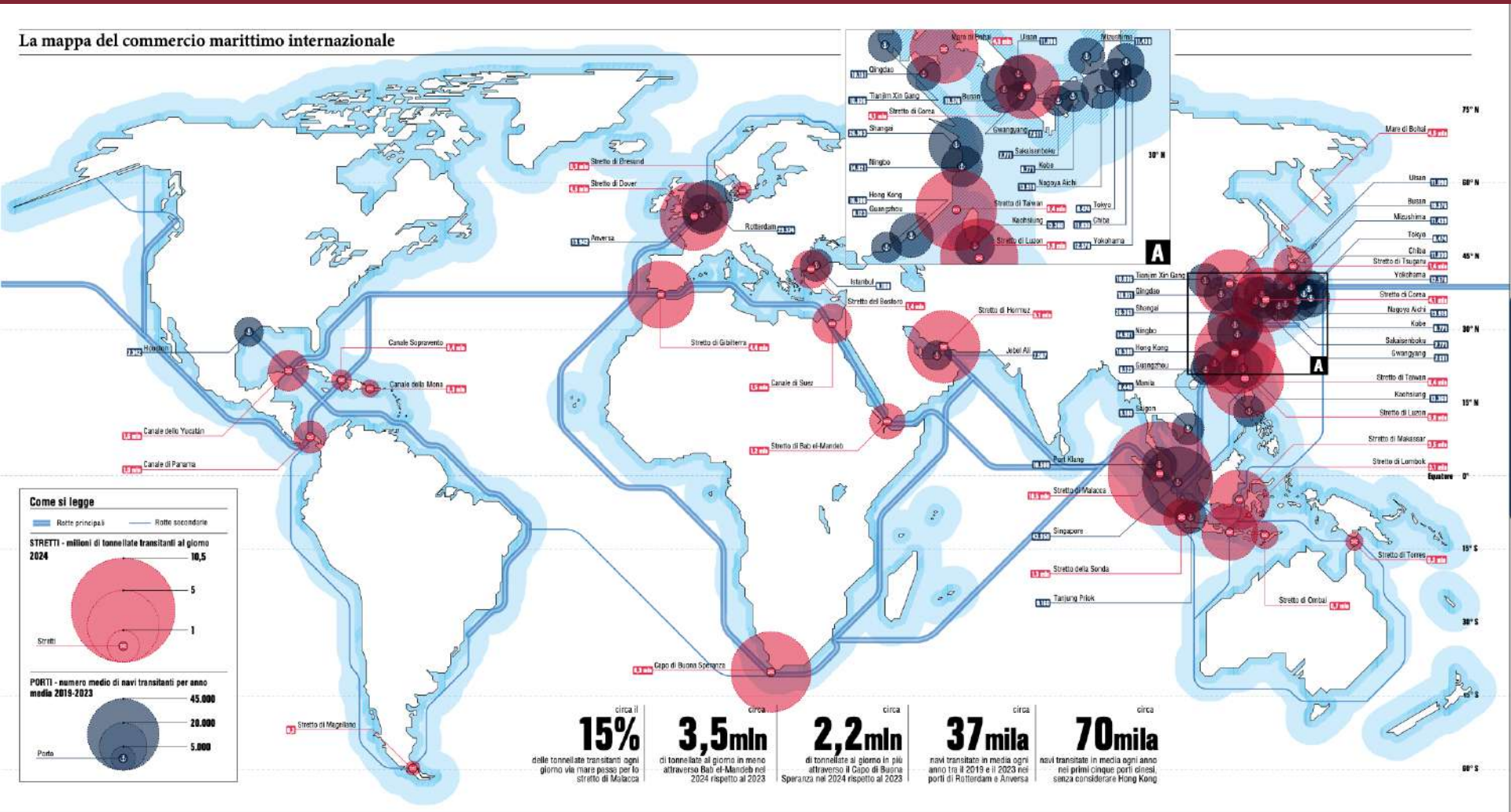


Figure 1- 6 Distribution of the Chinese Antarctica Research Stations (Base Map: COMNAP 2009)

Map shows China's main area of activity in Antarctica, what it calls the East Antarctic Sector.[10]

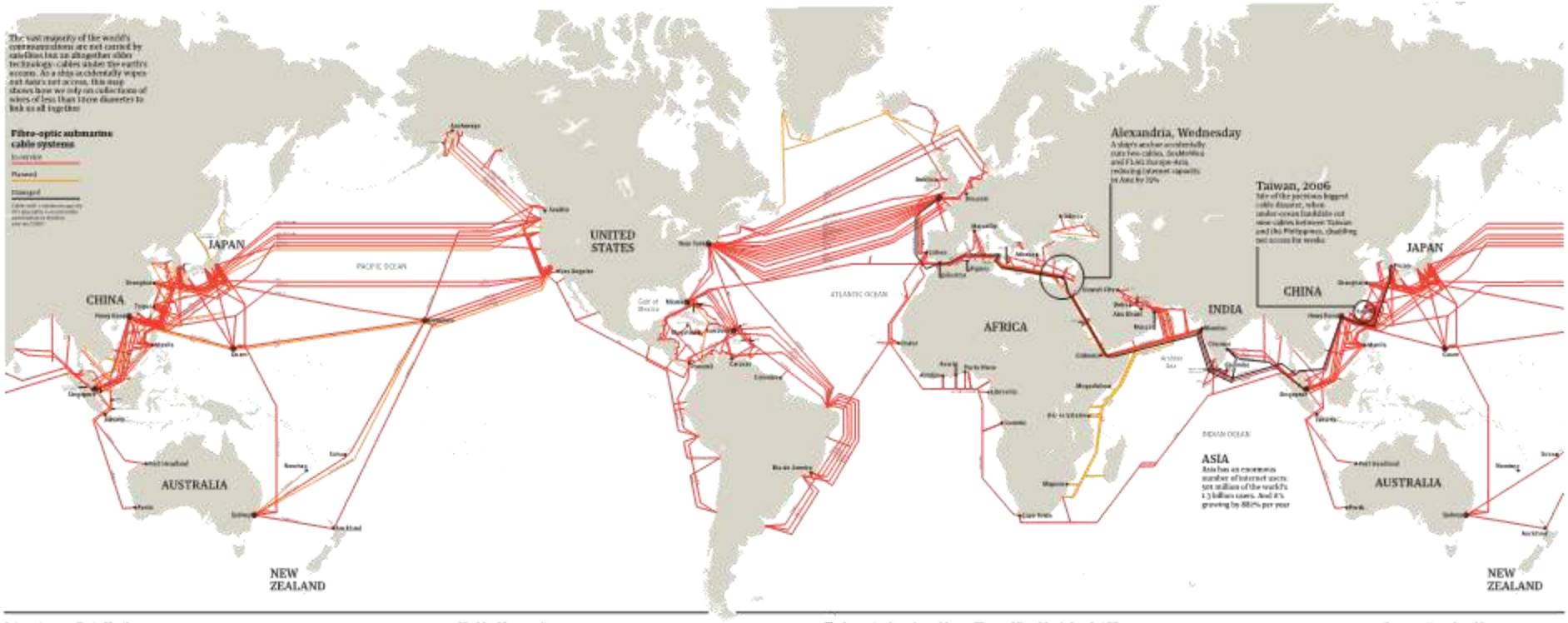
CHAPTER 2 – BECAUSE OF THE OTHER SEAS





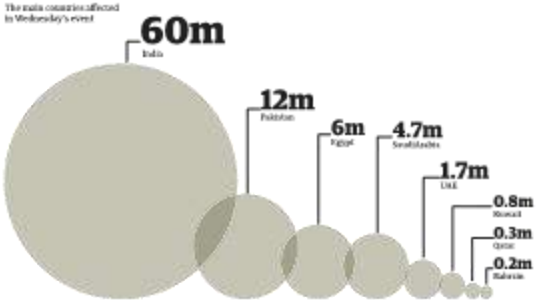
da Rapporto DIS 2023

The internet's undersea world



Internet users affected by the Alexandria accident

The main countries affected by Wednesday's event

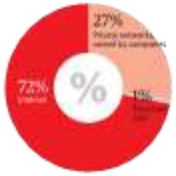


World cable capacity

Submarine cable operators light them self capacity on their systems to sell bandwidth to other carriers. Carriers buy extra capacity, mainly to hold in reserve. On the trans-Atlantic route 80% of the bandwidth is purchased, but only 29% is used

Capacity in terabytes a second

What makes up "used capacity"?



The longest submarine cables

The SeaMeWe-3 system from Nordes to Germany to Keoje, South Korea connects 32 different countries with 39 landing points

SeaMeWe-3	39,000 km
Southern Cross	30,500 km
China-US	20,476 km
FLAG Europe-Asia	28,000 km
South America-1	25,000 km

The world's cables in handwidth

The first intercontinental telephony submarine cable system, TAT-1, connected North America to Europe in 1958 and had an initial capacity of 640,000 bytes per second. Since then, total trans-Atlantic cable capacity has soared to over 7 trillion bps

Cross-section of a cable

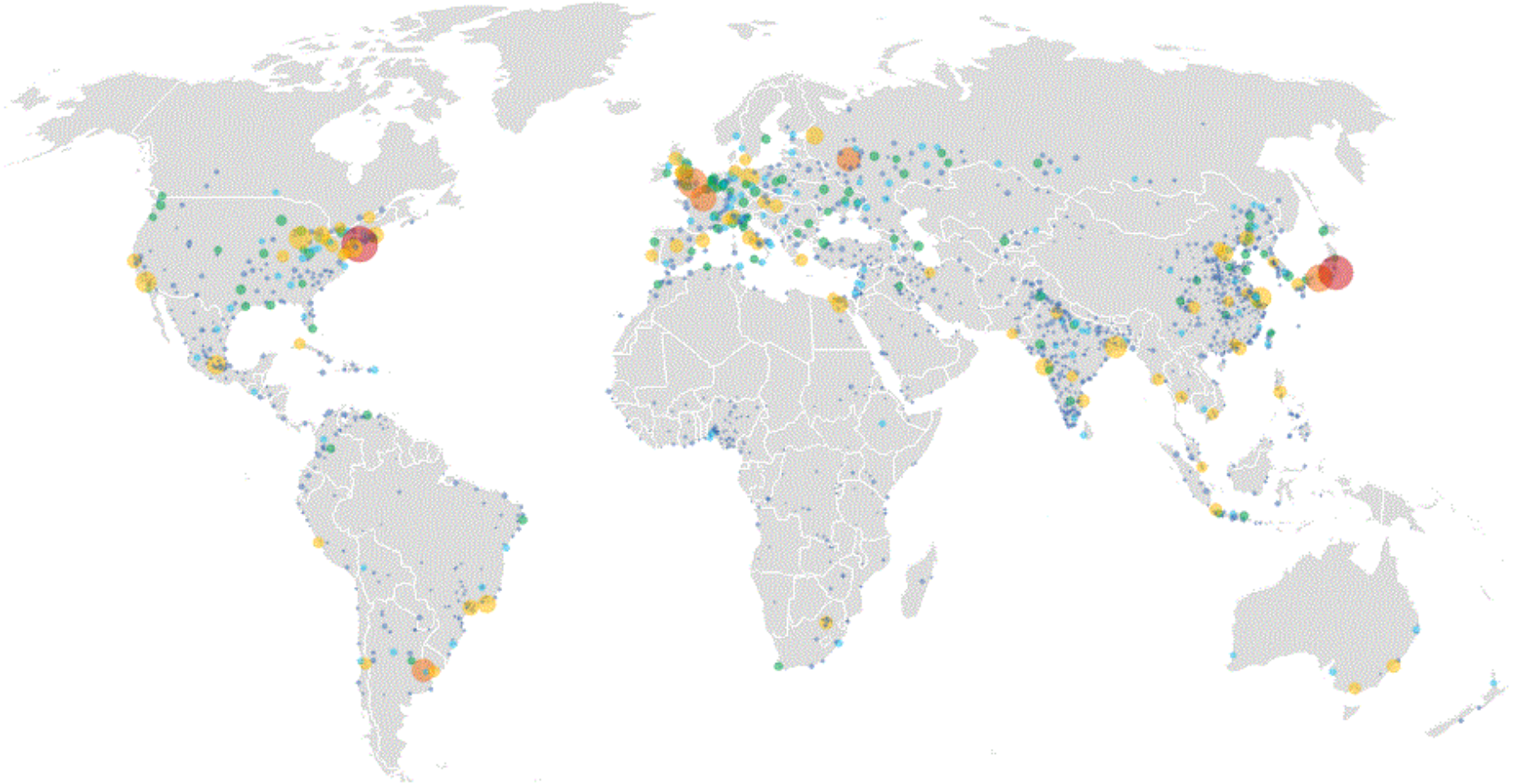
Cables of this strength are typically 69 mm in diameter and weigh over 10,000 kilograms a kilometer. In deeper waters, lighter and less insulated cables are used

Urbanisation, 1950

Search cities

GLOBAL CITY POPULATIONS*

70.4%	17.7%	2.0%	2.6%	5.1%	1.3%	0.9%
Rural -	Other urban Fewer than 300,000	Smallest cities 300,000 to 500,000	Small cities 500,000 to 1m	Medium cities 1m to 5m	Large cities 5m to 10m	Megacities 10m or more



1950 1960 1970 1980 1990 2000 2010 2020 2030

Source: UN

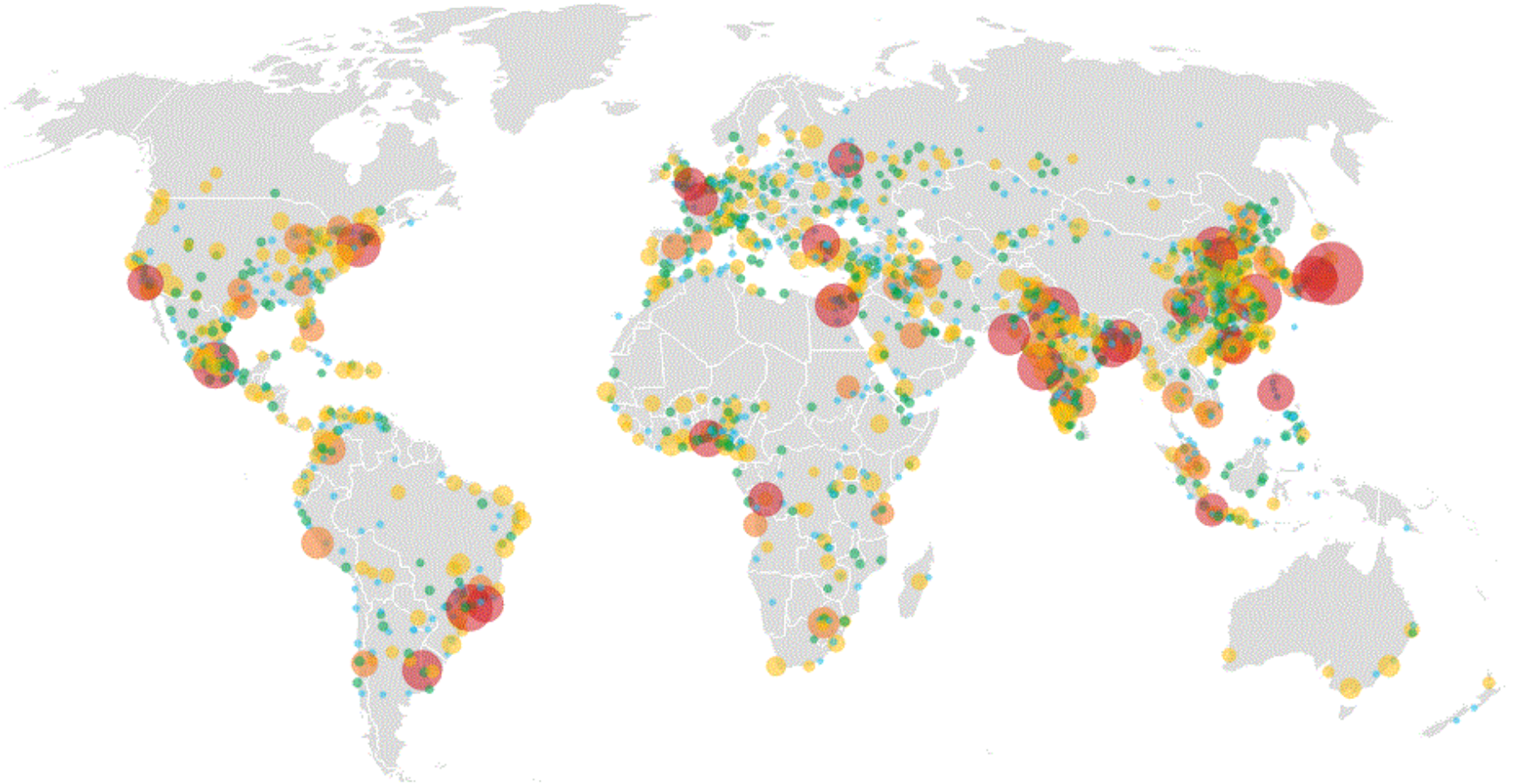
*Dataset comprises urban agglomerations with 300,000 inhabitants or more in 2014.
Data are for countries existing in 2014, mapped on modern borders. Projections from 2014.

Urbanisation, 2015

Search cities

GLOBAL CITY POPULATIONS*

46.0%	23.2%	3.6%	5.1%	11.6%	4.2%	6.4%
Rural -	Other urban Fewer than 300,000	Smallest cities 300,000 to 500,000	Small cities 500,000 to 1m	Medium cities 1m to 5m	Large cities 5m to 10m	Megacities 10m or more



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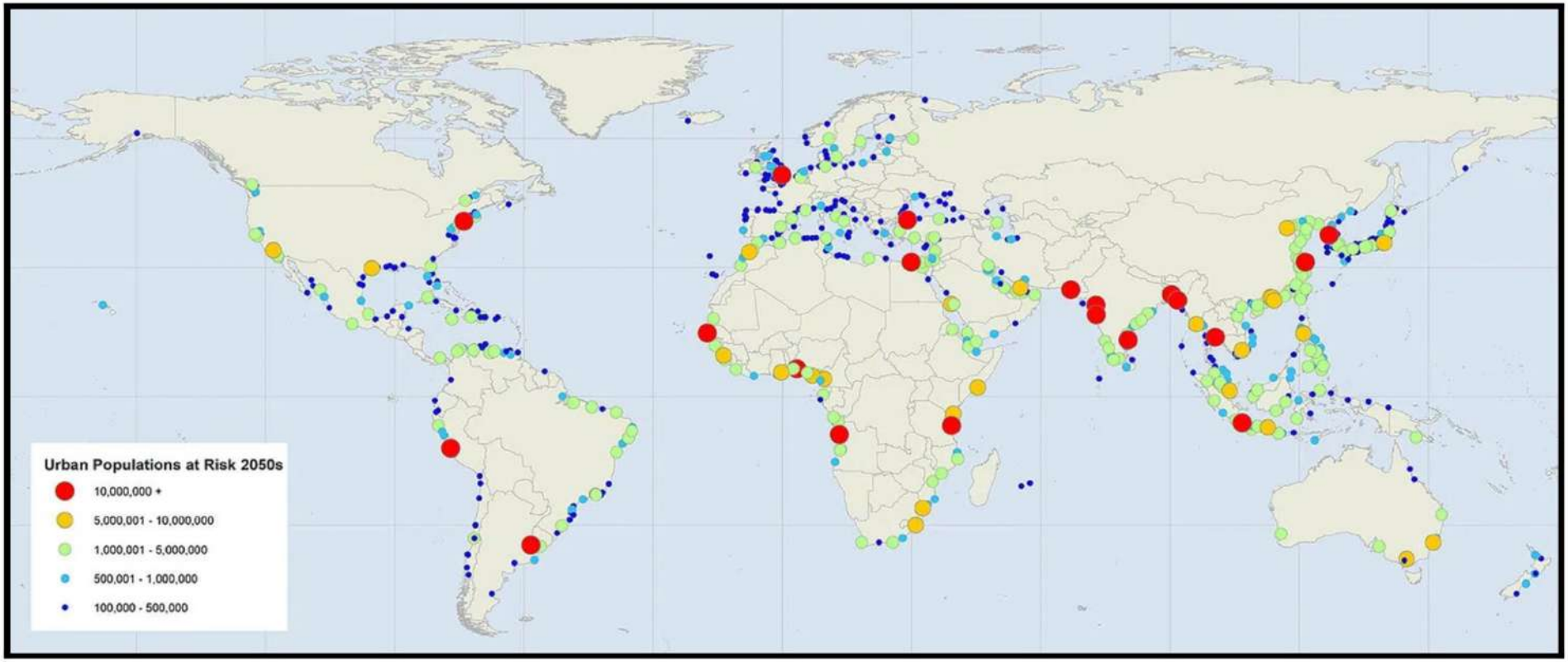
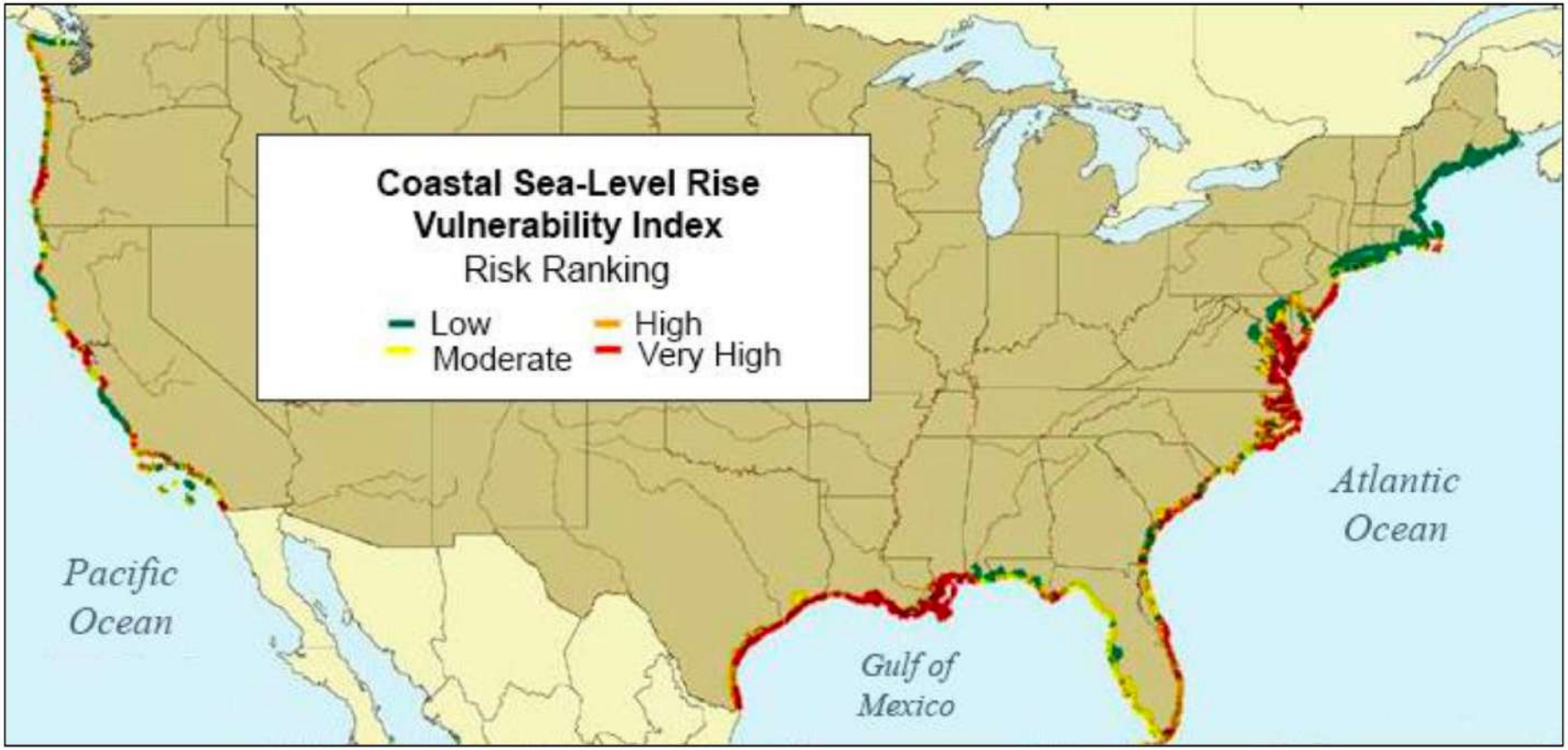


da *C40 Cities* 2025

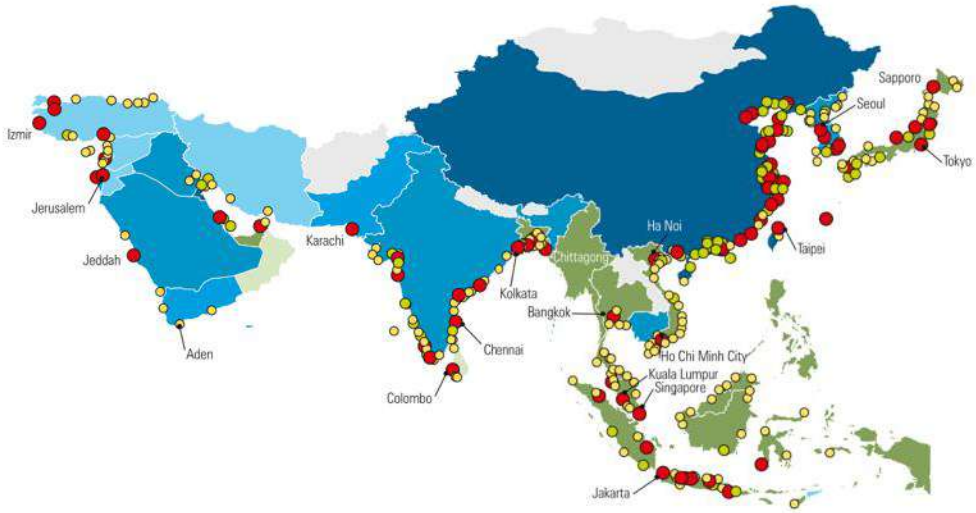
Figure 8. U.S. Coastal Vulnerability Index for the Atlantic, Pacific, and Gulf of Mexico



Source: U.S. Geological Survey, National Assessment of Coastal Vulnerability to Sea Level Rise, at http://woodshole.er.usgs.gov/project-pages/cvi/images/largenat.jpg. Full 2001 data series available at http://pubs.usgs.gov/dds/dds68/. Figure modified by CRS.

Notes: Although the USGS assessment did not analyze the coastal vulnerability of the Alaska, Hawaii, territories, or insular areas, the USGS analyzed some portions of those coasts. For example, a USGS-National Park Service collaboration provides information on some coastal shorelines in Alaska, Hawaii, Virgin Islands, American Samoa, and Guam at http://woodshole.er.usgs.gov/project-pages/nps-cvi/parks/parklist.html.

FIGURE 3.3.5: **ASIAN CITIES AT RISK DUE TO SEA-LEVEL RISE**



% of national urban population in urban LECZ

- Non LECZ
- 0.0 - 5.0
- 5.1 - 10.0
- 10.1 - 15.0
- 15.1 - 20.0
- 20.1 - 25.0
- > 25.0

City size

- Small
- Intermediate
- Big

Population of cities
Small: 100 - 500 thousand
Intermediate: 500 thousand - 1 million
Big: More than 1 million

N

0 2,000 4,000kms

Data source: Coastal Analysis Data Set utilizing GRUMP beta population and land area grids (CIESIN, 2005), Low elevation Coastal Zone created from SRTM elevation grid (CIESIN, 2006). GRUMP (Global Rural - Urban Mapping Project) is a project of the Center for International Earth Science Information Network (CIESIN) at the Earth Institute, Columbia University.

LECZ: Low Elevation Coastal Zones are land areas that are contiguous with the coast and ten metres or less in elevation.

All grids 1km resolution.

Source: UN-HABITAT Global Urban Observatory 2008

da *UN World's Cities Report* 2008-2009

Manila

Da Coastal Wiki 2025

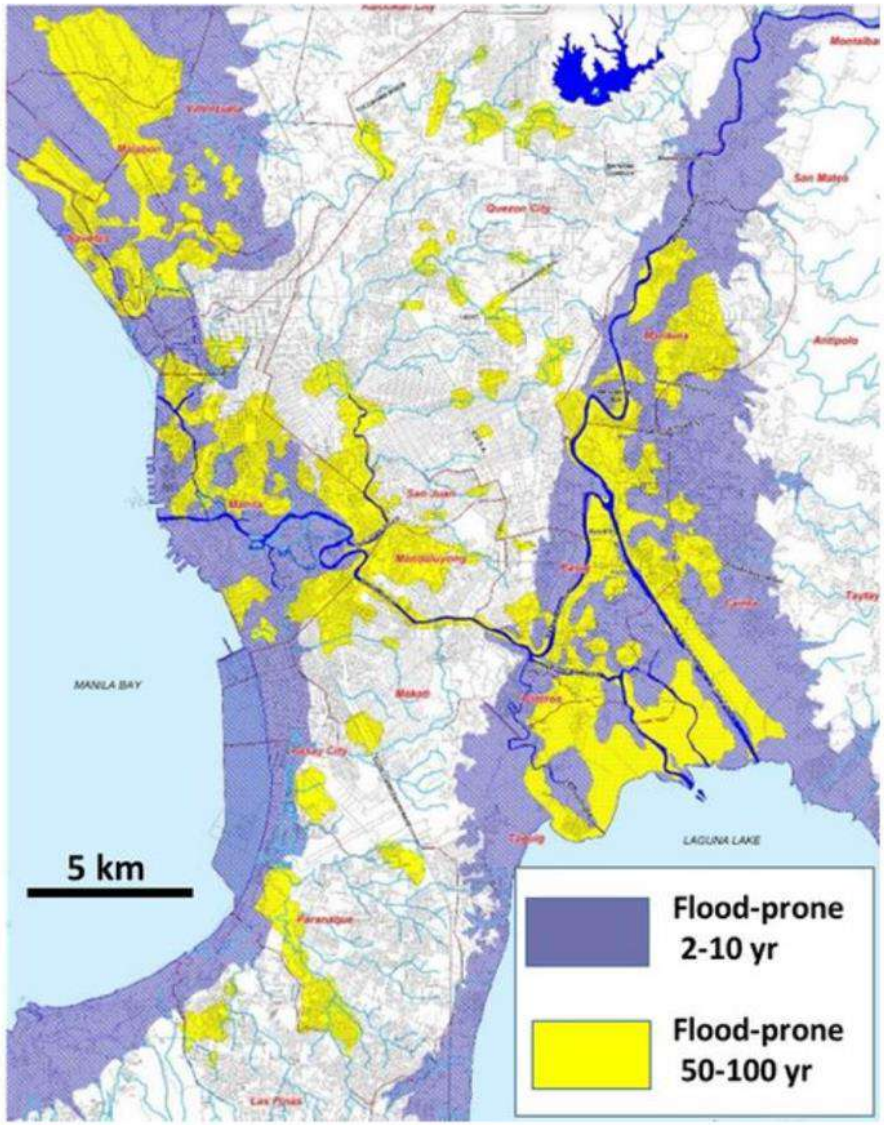


Fig. 12. Flood-prone zones of Manila. Image credit: Government of the Philippines, Mines and Geosciences Bureau.

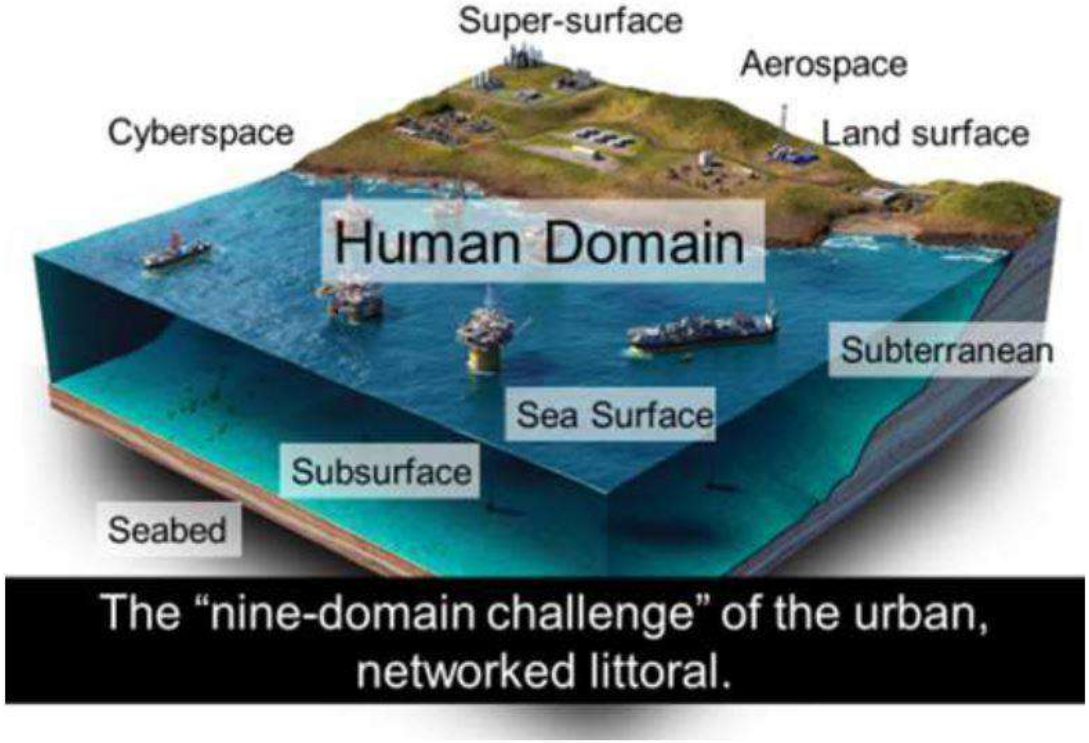
Responses

- Investments in flood defense structures: dikes, river embankments, improvement of waterways, modernization of the drainage infrastructure and pumping stations
- Increasing the water retention capacity, e.g. green and other infrastructure such as rooftop rainwater collection, green roofs, permeable pavements, and temporary retention of drainage water in public areas such as basketball courts and parking garages
- Upstream water retention ponds
- Solid waste collection
- Households in vulnerable areas adapt to flooding by raising floors and adding more floors to their dwellings
- Flood forecasting and early warning systems and community-based flood risk management
- Improved institutional structure to deal with flood management
- Relocation of the informal settlers from the most vulnerable neighbourhoods (inhabited by the poorest

The Role and Relevance of the Maritime Domain in an Urban-Centric Operational Environment

Study Paper

Kiel / Norfolk
2017



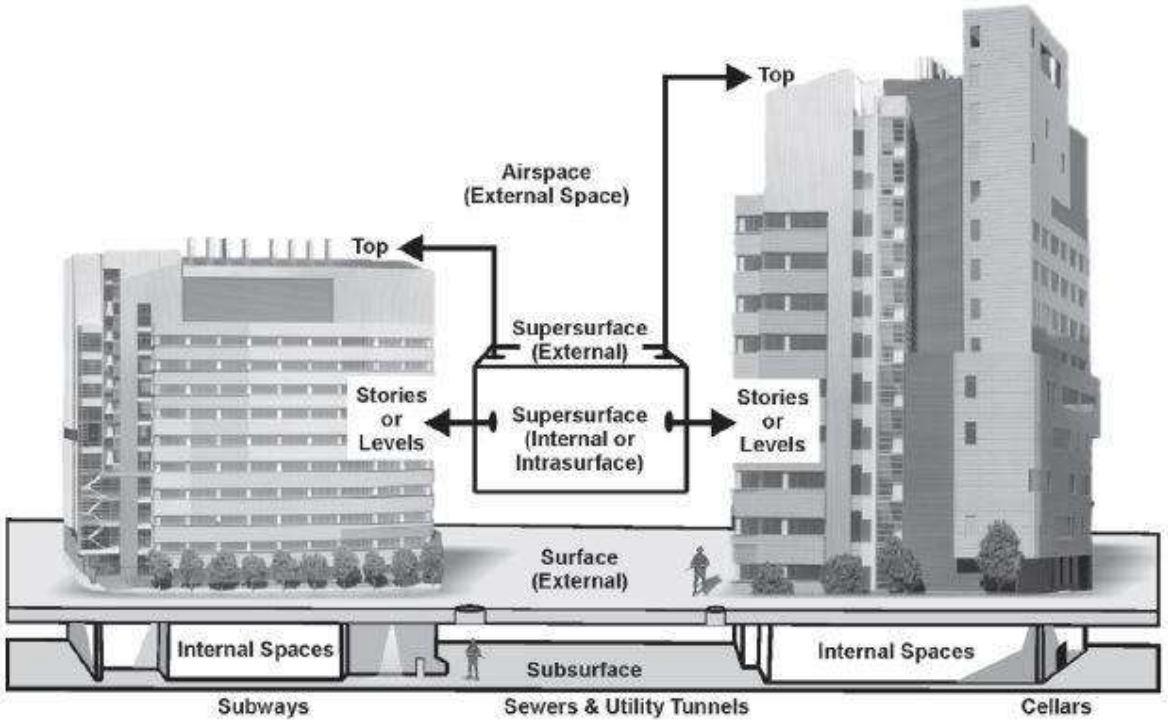
Source: David Kilcullen; Presentation at the Maritime Urbanisation Community of Interest Workshop in Hampton Roads, February 2015

Reimagining the Character of Urban Operations for the U.S. Army

How the Past Can Inform the Present and Future

Gian Gentile, David E. Johnson, Lisa Saum-Manning, Raphael S. Cohen, Shara Williams, Carrie Lee, Michael Shurkin, Brenna Allen, Sarah Soliman, James L. Doty III

Figure 3.2
Urban Battlespace



SOURCE: ATTP 3-06.11; FM 3-06.11.

RAND *RR1602-3.2*

AUMENTO DEL LIVELLO DEL MARE

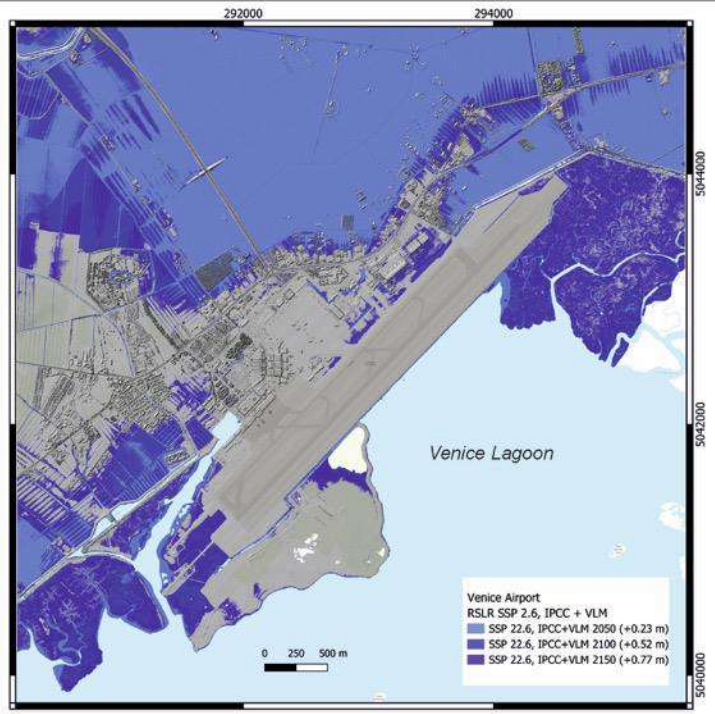
COSA È IMPORTANTE SAPERE PER AFFRONTARE I PROSSIMI CAMBIAMENTI

Funded by
the European Union
Civil Protection and Humanitarian Aid

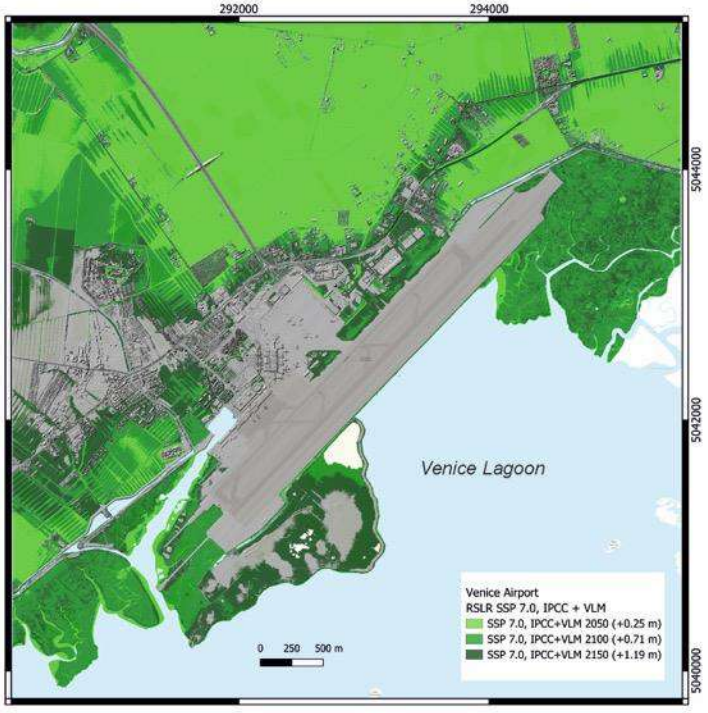
SAVEMEDCOASTS2

Uno sguardo d'insieme alle coste del Mediterraneo. In rosso sono evidenziate 163 piane costiere principali che si trovano entro circa due metri di altezza sul livello del mare. Queste zone, la cui superficie totale è di circa 38.529 km², pari a circa 5,5 milioni di campi di calcio o alla Svizzera, sono esposte al rischio di aumento del livello marino e ai conseguenti effetti. In condizioni di livello marino più alto di oggi, nei prossimi decenni potrebbero essere in parte sommerse e subire l'amplificazione degli effetti di tempeste e tsunami.


1372000
1376000
5692000
5688000
Venice
RSLR SSP 2.6, IPCC + VLM
SSP 22.6, IPCC+VLM 2050 (+0.23 m)
SSP 22.6, IPCC+VLM 2100 (+0.53 m)
SSP 22.6, IPCC+VLM 2150 (+0.79 m)
0 250 500 m
Venice Lagoon


292000
294000
5044000
5042000
5040000
Venice Lagoon
Venice Airport
RSLR SSP 2.6, IPCC + VLM
SSP 22.6, IPCC+VLM 2050 (+0.23 m)
SSP 22.6, IPCC+VLM 2100 (+0.52 m)
SSP 22.6, IPCC+VLM 2150 (+0.77 m)
0 250 500 m


1372000
1376000
5692000
5688000
Venice
RSLR SSP 7.0, IPCC + VLM
SSP 7.0, IPCC+VLM 2050 (+0.25 m)
SSP 7.0, IPCC+VLM 2100 (+0.72 m)
SSP 7.0, IPCC+VLM 2150 (+1.21 m)
0 250 500 m
Venice Lagoon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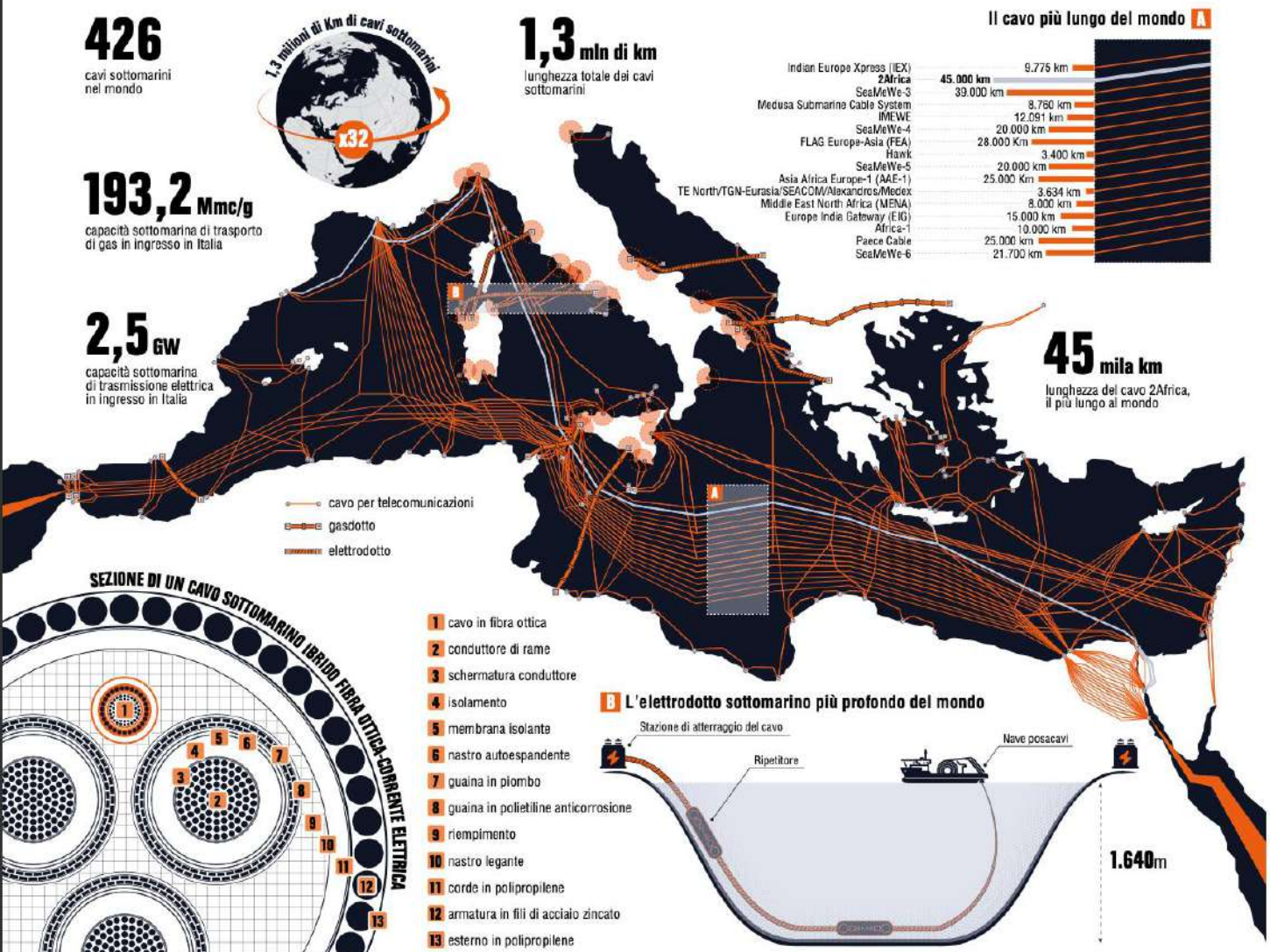
Venice Lagoon
Venice Airport
RSLR SSP 7.0, IPCC + VLM
SSP 7.0, IPCC+VLM 2050 (+0.25 m)
SSP 7.0, IPCC+VLM 2100 (+0.71 m)
SSP 7.0, IPCC+VLM 2150 (+1.19 m)
0 250 500 m

Infrastrutture critiche sottomarine nel Mediterraneo

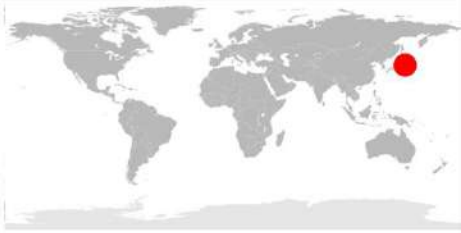
Il territorio italiano è parte di un'articolata rete infrastrutturale sottomarina composta da cavi per le telecomunicazioni, gasdotti ed elettrodotti la cui tutela costituisce una priorità per la sicurezza nazionale, anche in considerazione della posizione strategica del nostro Paese nell'area mediterranea.



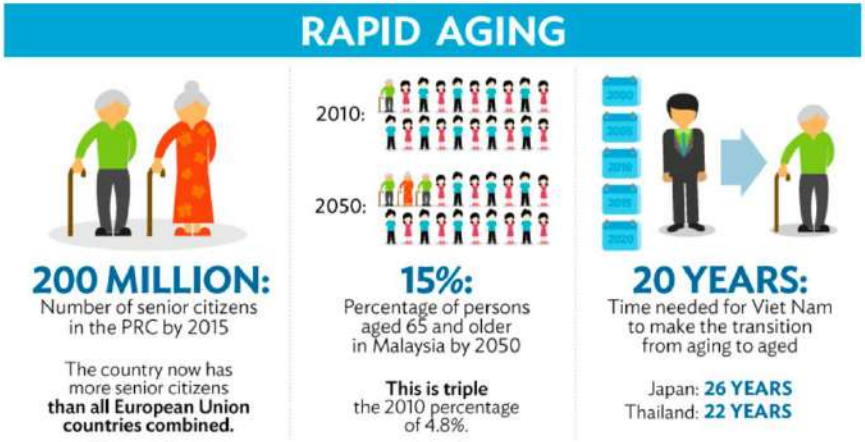
da Rapporto DIS 2023

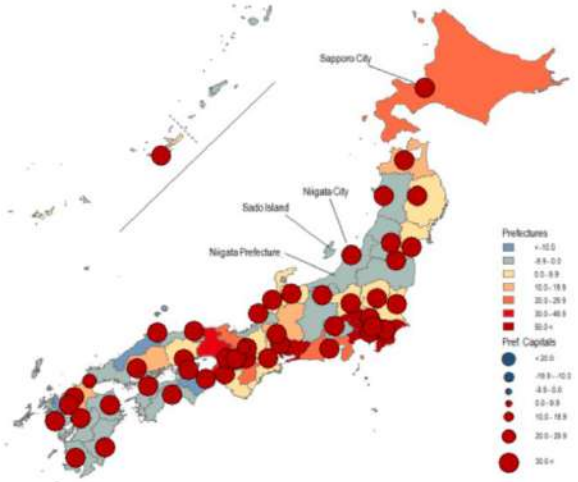
WICH EPILOGUE?

More of these issues will happen with climate change and the ageing population



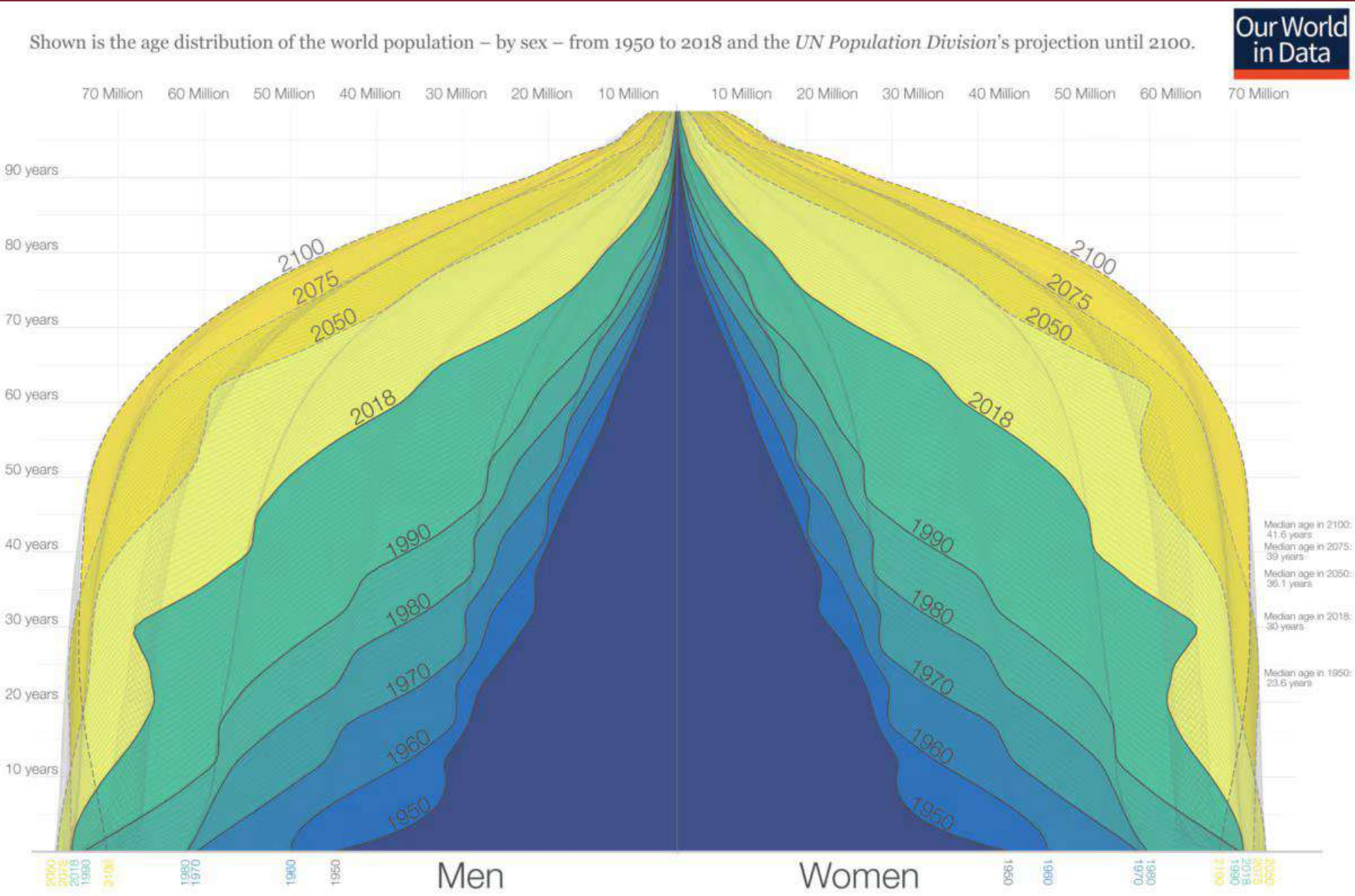
The population decline is particularly severe in the country side, as the Japanese regroups in cities, and mostly in the Kanto and Kansai areas.





... and although it is tempting to think that population transfer may occur from other countries in Asia, similar issues are rising in East Asia, and one should not count on those countries to bridge the population gap, especially in a slowing economy (Japan won't have the shine it enjoys today).

da Gomez 2022


Shown is the age distribution of the world population – by sex – from 1950 to 2018 and the *UN Population Division*'s projection until 2100.
Our World in Data
70 Million
60 Million
50 Million
40 Million
30 Million
20 Million
10 Million
90 years
80 years
70 years
60 years
50 years
40 years
30 years
20 years
10 years
2100
2075
2050
2018
1990
1980
1970
1960
1950
Median age in 2100: 41.6 years
Median age in 2075: 39 years
Median age in 2050: 36.1 years
Median age in 2018: 30 years
Median age in 1950: 23.6 years
Men
Women
Data source: United Nations Population Division – World Population Prospects 2017; Medium Variant.
The data visualization is available at OurWorldinData.org, where you find more research on how the world is changing and why.
Licensed under CC-BY by the author Max Roser.

THANKS FOR YOUR ATTENTION!

piero.cimbollispagnesi@uniroma1.it