Climate change impacts on cetaceans and their prey – predicted and observed effects

INTERNATIONAL WHALING COMMISSION

- # Climate change impacts on cetaceans and their prey – predicted and observed effects

Tilen Genov – Morigenos - Slovenian Marine Mammal Society

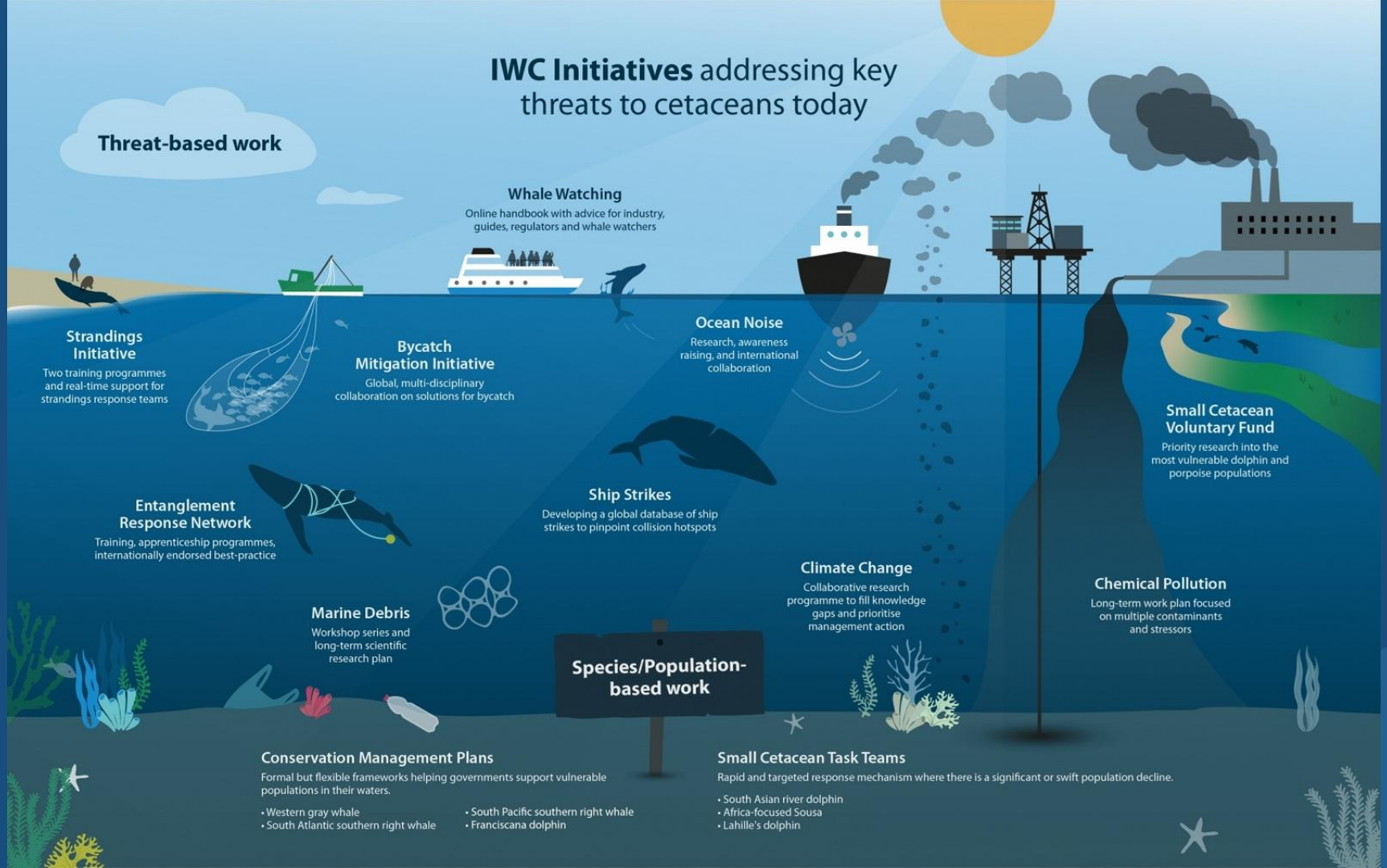
Laetitia Nunny – OceanCare

Lindsay Porter – Chair, IWC Scientific Committee

Mark Simmonds - CMS CoP-Appointed Councillor, Convener of IWC Climate Change Intersessional Group

Vanesa Tossenberger - CMS CoP-Appointed Councillor, Argentina Scientific Councillor and Fundación Cethus

Viv Tulloch - Basin Scale Events to Coastal Impacts (BECI)


IWC Initiatives addressing key threats to cetaceans today
Threat-based work
Whale Watching
Online handbook with advice for industry, guides, regulators and whale watchers
Strandings Initiative
Two training programmes and real-time support for strandings response teams
Bycatch Mitigation Initiative
Global, multi-disciplinary collaboration on solutions for bycatch
Ocean Noise
Research, awareness raising, and international collaboration
Small Cetacean Voluntary Fund
Priority research into the most vulnerable dolphin and porpoise populations
Entanglement Response Network
Training, apprenticeship programmes, internationally endorsed best-practice
Ship Strikes
Developing a global database of ship strikes to pinpoint collision hotspots
Climate Change
Collaborative research programme to fill knowledge gaps and prioritise management action
Chemical Pollution
Long-term work plan focused on multiple contaminants and stressors
Marine Debris
Workshop series and long-term scientific research plan
Species/Population-based work
Conservation Management Plans
Formal but flexible frameworks helping governments support vulnerable populations in their waters.
• Western gray whale
• South Atlantic southern right whale
• South Pacific southern right whale
• Franciscana dolphin
Small Cetacean Task Teams
Rapid and targeted response mechanism where there is a significant or swift population decline.
• South Asian river dolphin
• Africa-focused Sousa
• Lahille's dolphin

Commission Meeting

Scientific Committee

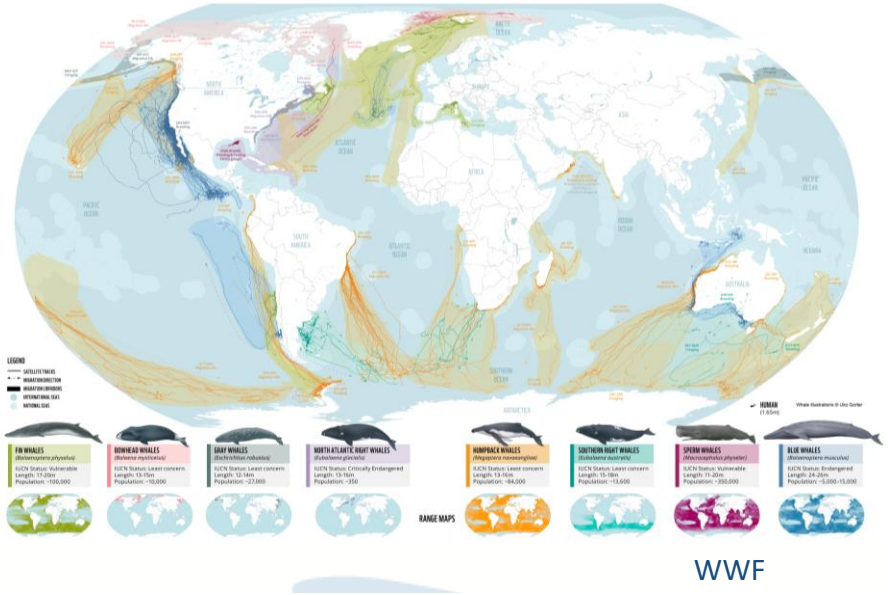
The Whale-Climate Connection

Migratory Baleen Whales

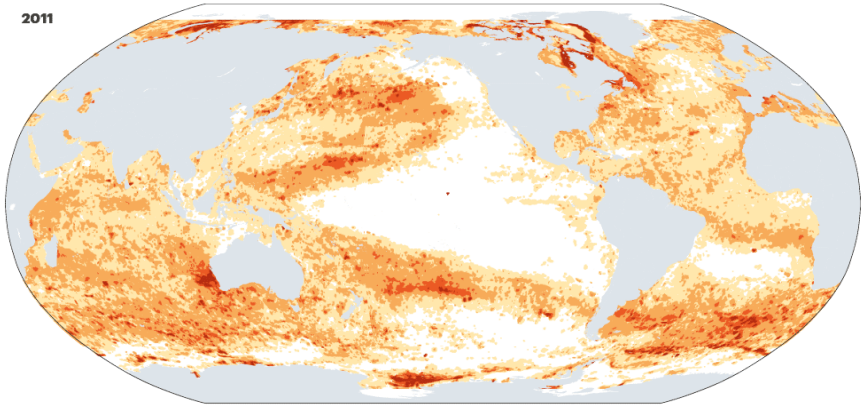
- Seasonal movements between feeding and breeding grounds
- Timing evolved to match prey availability and breeding requirements
- Historical fidelity to specific routes and regions
- Key species examples: Humpback, Gray, Blue, and Fin whales

Ocean Changes

- Rising sea temperatures
- Changing distribution and abundance of prey
- Sea ice extent reduction in polar feeding grounds
- Shifts in timing of spring phytoplankton blooms
- Altered upwelling patterns in productive regions



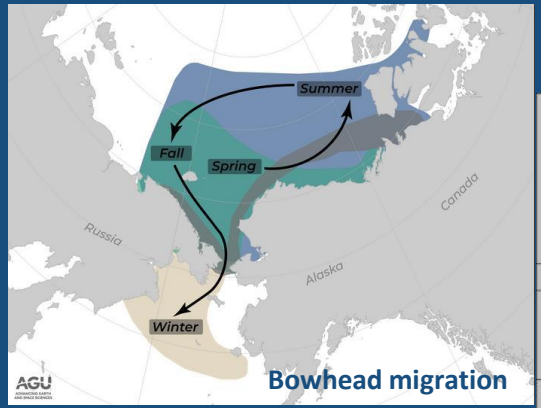
WWF



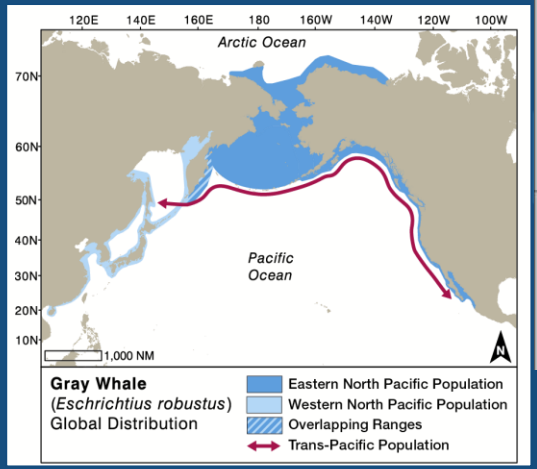
NOAA

Observed Effects – Migration, Habitat, Distribution

- **Physical Distribution**
  - Changes in migration timing, distribution patterns
  - Expansions into novel areas (e.g., arctic ice-free)
- **Physiological**
  - Reduced body condition in some populations
  - Nutritional stress resulting in increased mortality
- **Reproductive**
  - Altered breeding schedules and breeding success
  - Decreased calving associated with low prey availability
- Examples
  - Pacific Gray whales;
  - Humpback whales arriving in Antarctica;
  - Bowhead whales in the Arctic, crossing Pacific/Atlantic



Szesciorka et al. 2024

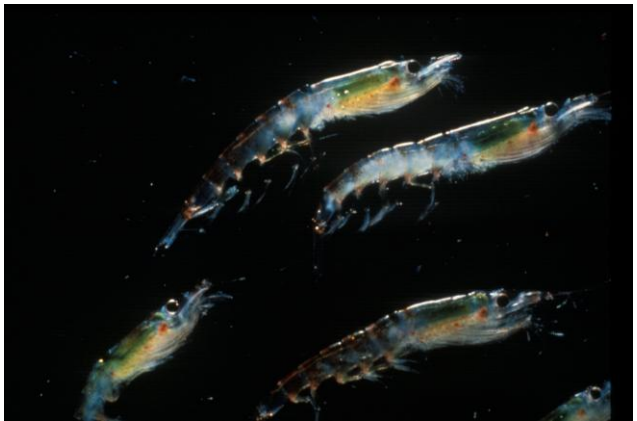


IWC – grey whale range

Region	Species	Observed Impacts: maximum latitude	habitat availability	migration dates	time spent in high latitude	visual/acoustic detections	strandings	other
Arctic	Bowhead whale		↓					
	Narwhal		↓					
	Beluga		↓	↓		↑↓		
Subarctic	Humpback whale	↑		↑		↑		
	Fin whale	↑		↑		↑		
	Common minke whale	↑				↑		
	Blue whale	↑		↑				
	Sperm whale	↑						
	Killer whale					↑↓	↓	
	Grey whale			↓				
	North Pacific right whale							
	North Atlantic right whale					↑		
Other	Bryde's whale					↑		
	Humpback whale					↑		
	Fin whale					↑		
	Blue whale					↓		
	Antarctic minke whale							
	Killer whale						↓	

Van Weelden et al. 2021

Bottom-up Pathways of Climate Impacts



Prey impacts

- Shifts in plankton communities (geographical and seasonal)
  - Changes in timing of peak zooplankton abundance
  - Alterations in copepod community composition
- Changes in krill abundance and distribution, shifts northwards
- Alterations in timing of peak productivity

Whale impacts

- Migratory routes, critical habitat changes, energetic considerations
- Localised depletion?
- Competition for prey
- Prey switching, diet changes

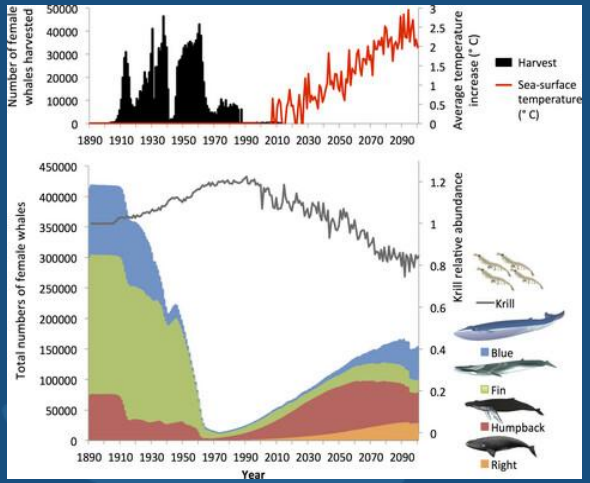
- Examples: Changes in North Atlantic right whale distribution relative to prey shifts; Southern Pacific Humpback Whales

Future Pathways and Predicted Impacts

	Species	Change in habitat characteristics or availability						Change to food supply or distribution				Other
		Range shift/contraction	Range shift/expansion	Habitat change	Altered breeding/migratory phenology	Altered predator interaction/exposure	Altered breeding success/ calving rates	Altered prey abundance/ availability	Prey selection/shifting	Competition for prey	Altered prey accessibility	Direct mortality/survival
SOUTHERN HEMISPHERE	Antarctic Minke Whale*	▼		▲▼				▬		▲▼		
	Blue Whale*		■					▲▼		▲▼		
	Fin Whale*		▼					▼		▼		
	Humpback Whale		▲		▬			▼		▼		
	Southern Right Whale*		■	▼			▼	▲▼		▲▼		▼
NORTHERN HEMISPHERE	Blue Whale		■		▼			■			▲	
	Bowhead Whale	▼		▲▼	▼	▼		▬				
	Common Minke Whale	▼	■	■				▼	▼	▼	▼	
	Fin Whale		▼		▬			■	■	■		
	Grey Whale		■	▲	■		▲				▲	▼
	Humpback Whale		■		▲▼			▲	▬		▲	
	North Atlantic Right Whale	▼	▬	▼	▼			▼			■	
	North Pacific Right Whale*		▲									

•Differs across species, oceans, latitudes

- Habitat availability changes
- Changes in migration patterns
- Expected shifts in prey availability - likely impacts on energetics, reproduction rates
- Potential new connectivity between populations (e.g., ice-free regions)
- Increased predation in novel habitats



Tulloch et al. 2019

•Prey-mediated responses dominate Southern Hemisphere observations and predictions

Migratory baleen whale populations most vulnerable to climate change

Right Whales

Arctic and Subarctic Whales

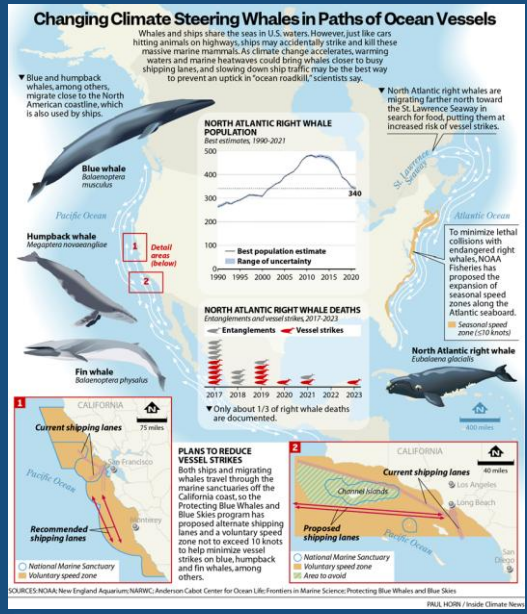
Gray Whales

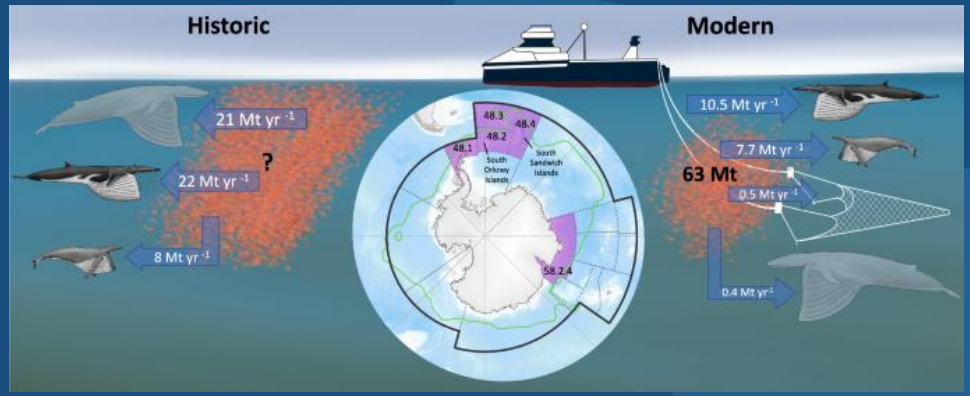
Ice-dependent Antarctic Whales

Cumulative Impacts - Potential Avenues for action

Observed and expected impacts

- Shipping route changes due to ice melt
- Increased or changing fishing activities in new areas
- Increased interactions with other human activities (noise, vessel strikes, pollution)
- Disease susceptibility changes
- High uncertainty of interactive effects of multiple stressors





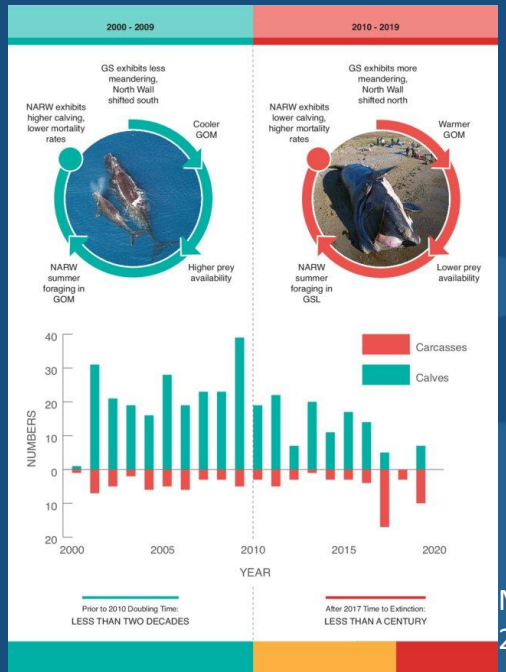
Savoca et al. 2024

Case Study: North Atlantic Right Whales, Shipping, Climate Change

- Shifting prey distribution affecting traditional feeding grounds
- Regime shifts in Gulf of Maine/Scotian Shelf from warming waters
- Increased whale movement into shipping lanes
- Vessel strikes, reduced calving rates
- Population impacts and recovery challenges

Problem: Mismatches in novel distributions under climate change with shipping lanes and vessel traffic

- Climate-informed solutions:
  - Vessel speed limits
  - Seasonal and dynamic management areas
  - Precautionary vessel routing changes
  - Mandatory ship reporting



Meyer-Gutbrod et al. 2021

Case Study: Climate Change and Whale-Fishery Interactions

California Case Study

Climate Change Impact

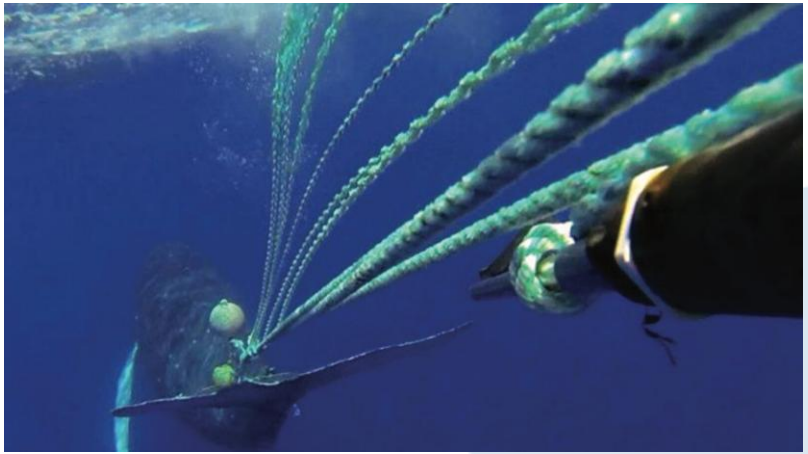
- Ocean warming shifts whale migration
- Increased overlap with crab fishing zones
- Higher entanglement risk

Management Innovations

- Dynamic time-area closures
- Gear modification requirements
- Real-time whale detection systems

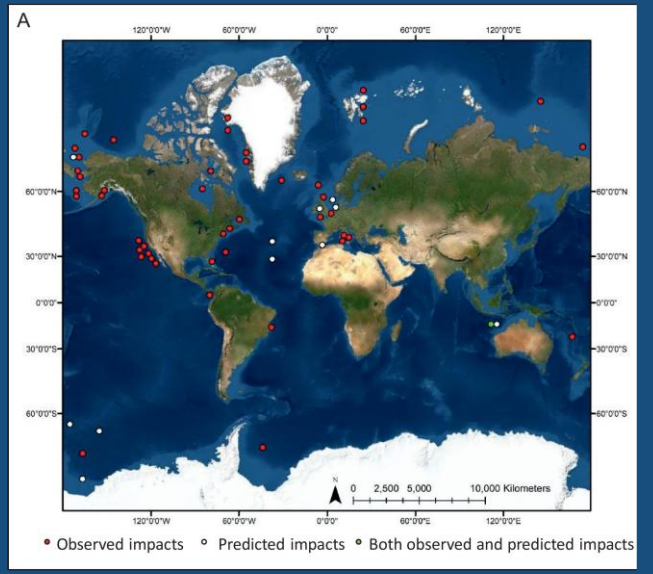
Key Intervention Outcomes

- 40% reduction in whale entanglements
- Collaborative fishery-conservation approach
- Adaptive seasonal fishing restrictions

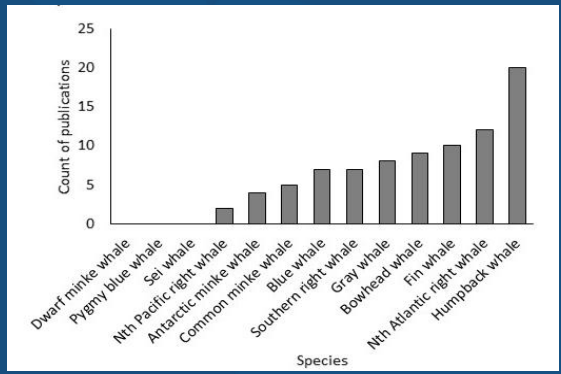


Research Gaps

- **Endangered Species:** Studies on vulnerable and/or data-deficient species e.g., North Pacific right whales and sei whales; Southern Hemisphere populations
- **Geographic Coverage:** understudied regions – Southern Ocean, Indian Ocean and South Atlantic
- **Migration pattern dynamics:** tracking route changes, reproductive success
- **Physiological adaptation mechanisms:** metabolic responses, genetic adaptation
- **Ecosystem interaction uncertainties:** predator-prey studies, food web structure changes



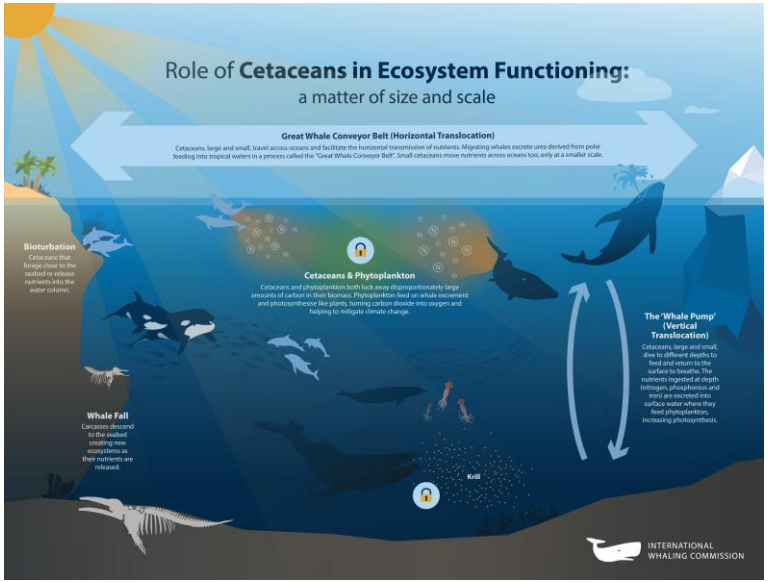
Van Weelden et al. 2021

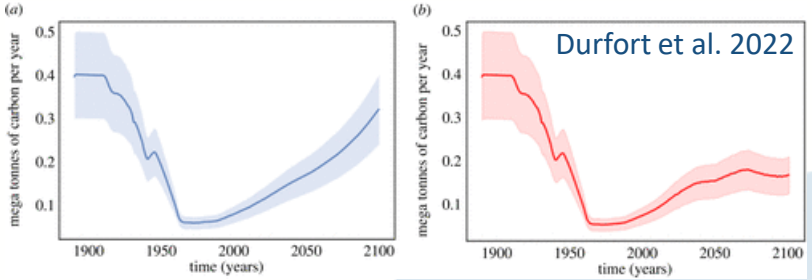


Tulloch et al. in press

Supporting ecosystem services and functioning

- **Whales-Ecosystem services-Climate change**
  - climate regulation through carbon sequestration (“whale falls”)
  - nutrient cycling contributing to primary productivity (“whale pump”)
  - food web stability
- **Conservation Implications:**
  - Protecting whale populations = Natural climate solution
  - Estimated value: $1 trillion in ecosystem services
  - Recovery could increase ocean carbon capture by 1.7 billion tons
- IWC workshops on ecosystem structure and functioning





UN environment programme

Convention on the Conservation of Migratory Species of Wild Animals

CMS

7th Meeting of the Sessional Committee of the CMS Scientific Council (ScC-SC7)

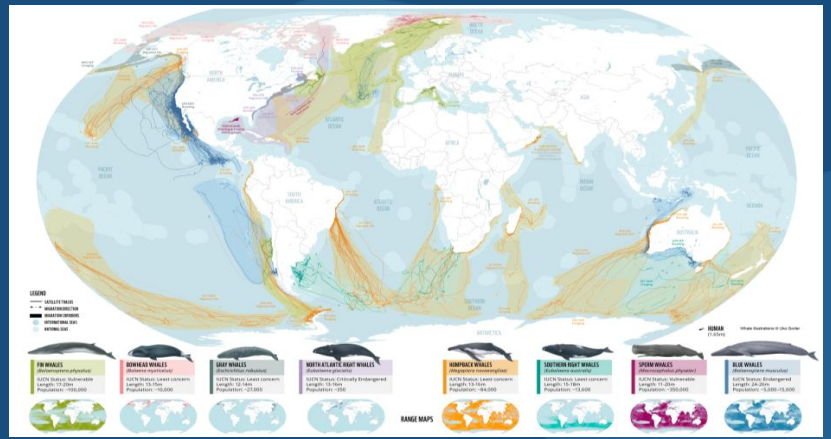
Bonn, Germany, 17 – 20 September 2024

UNEP/CMS/ScC-SC7/Inf.6.2.1

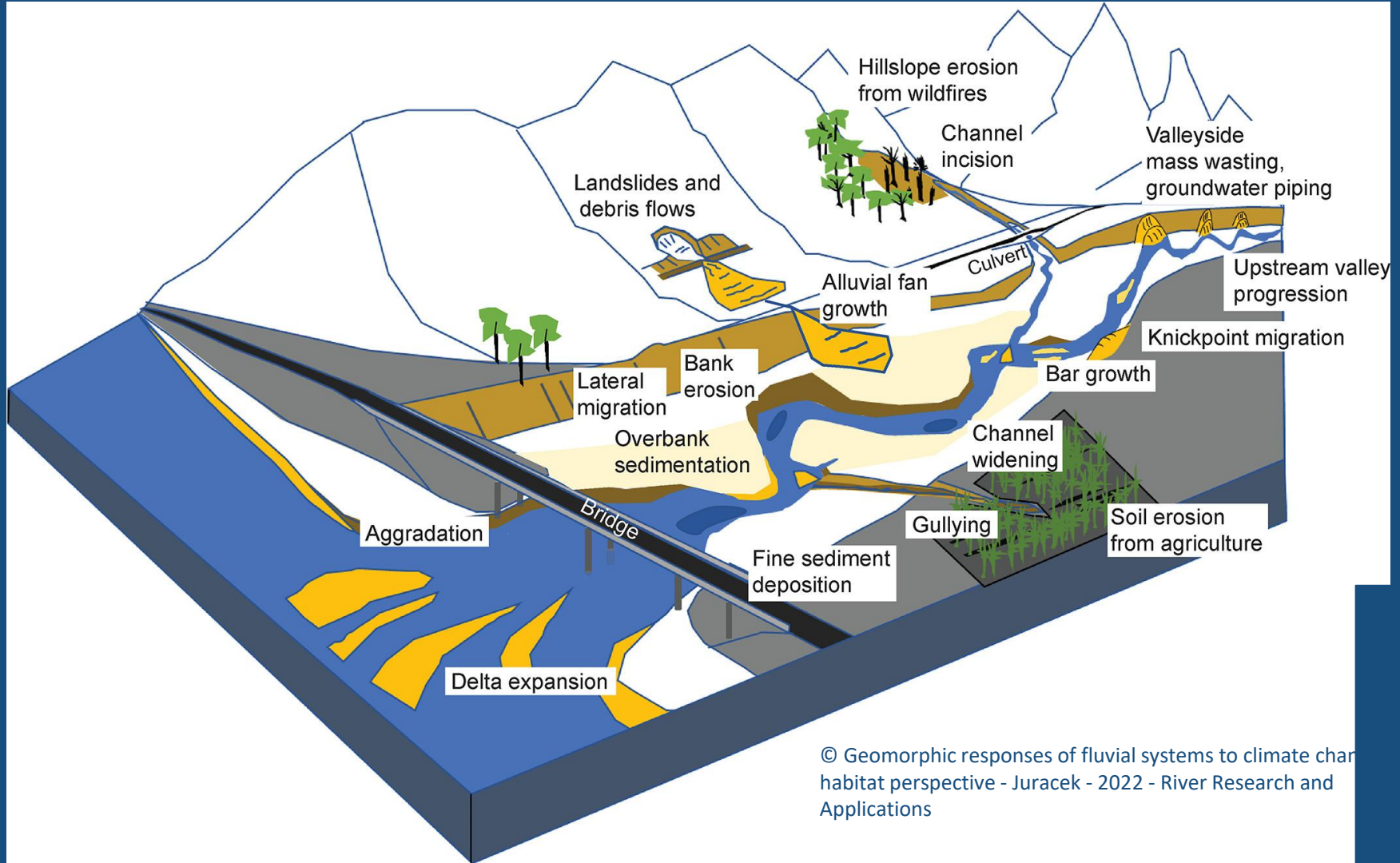
REPORT OF THE 2ND IWC-CMS WORKSHOP ON CETACEAN ECOSYSTEM FUNCTIONING

Climate Change Mitigation and Adaptation

- Protect and restore marine ecosystems that support whale food webs
- Monitor shifting prey distribution and create adaptive marine conservation corridors
- Support research on whale population response to changing ocean conditions



Climate Change Effects on Habitats



Climate Change Effects on Habitats

Impacts to River Dolphins

Irrawaddy Dolphin, Mekong River, Cambodia
© Lindsay Porter/SEAMAR

Nam Tha 1, Bokeo Province, Laos.
© Taylor Weidman/Bloomberg via Getty Images

Climate Change Effects on Habitats

Impact to Coastal Dolphins

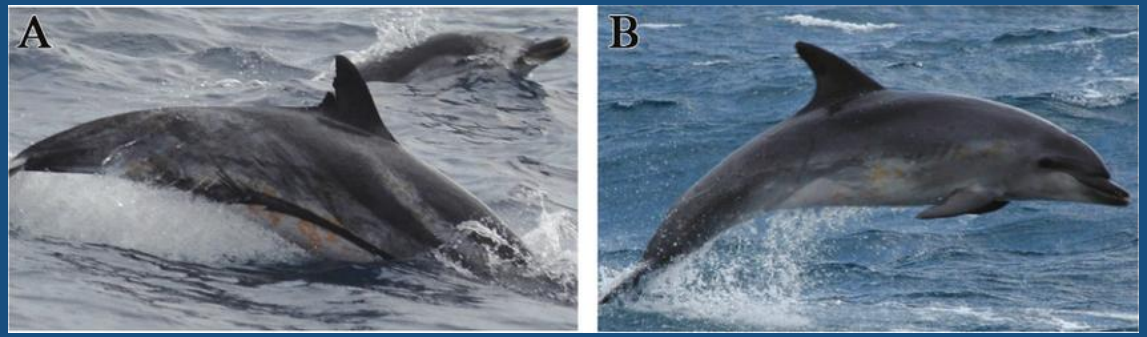
Climate Change Effects on Habitats

Impacts to River Dolphins

Indo-Pacific Humpback Dolphin, Hong Kong SAR

Climate Change Effects on Habitats

Prey shifts



Herr, H., et al. 2020. Injuries, Malformations, and Epidermal Conditions in Cetaceans of the Strait of Gibraltar. *Aquatic Mammals*, *46*(2).

River Dolphins: Case Study

IWC Recommendations

Attention: SC, CC, CG-Brazil, CG-Colombia, CG-Ecuador, CG-Peru

Considering the serious climate situation in the central Amazon in 2023 and the possibility that it will continue to occur, the Committee **recommends**

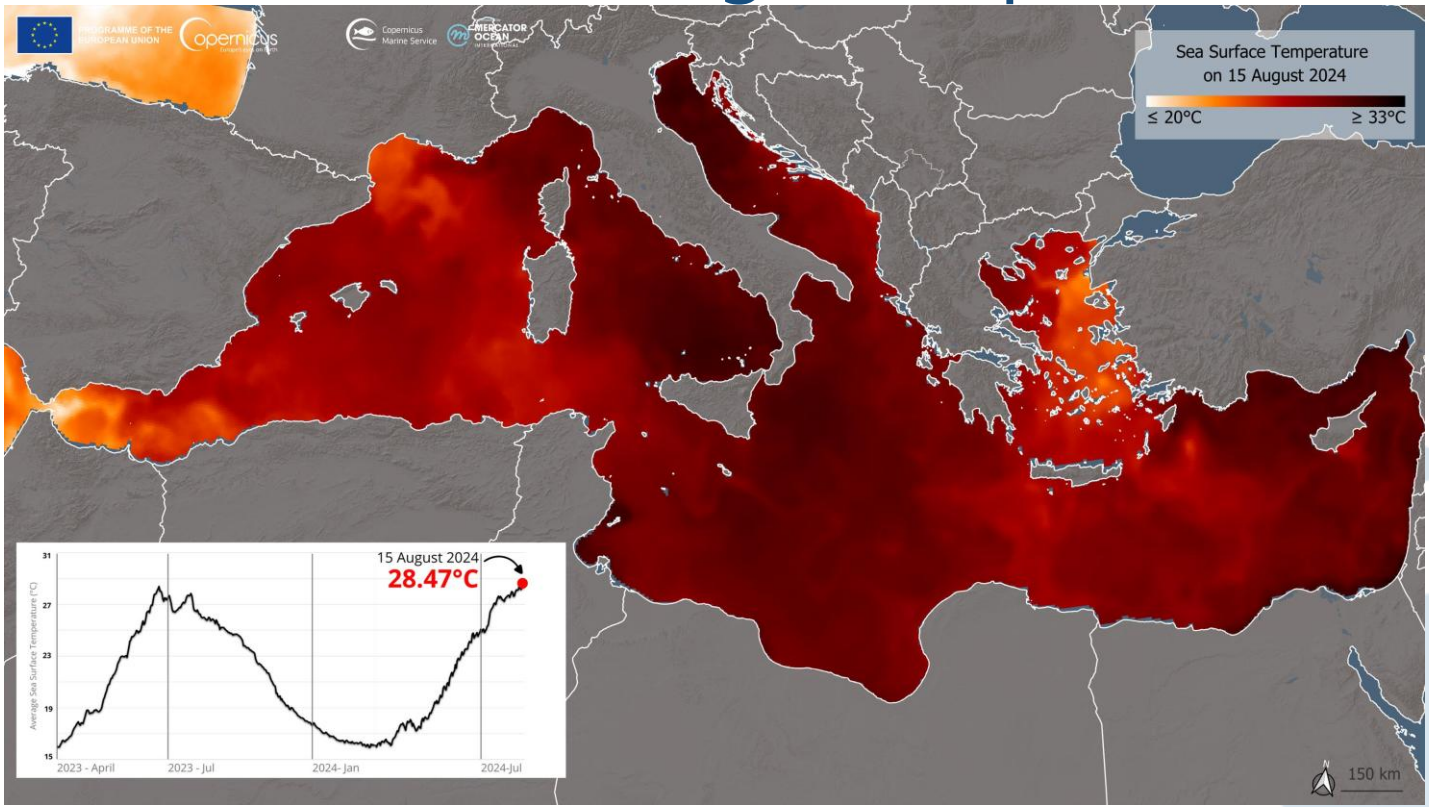
- a new line of work be included in the CMP [Conservation Management Plan] focused on climate impacts on river dolphins, in the generation of an early warning system, management protocols, and the training of fishers, veterinarians and biologists.

The Committee **reiterates** the following, including:

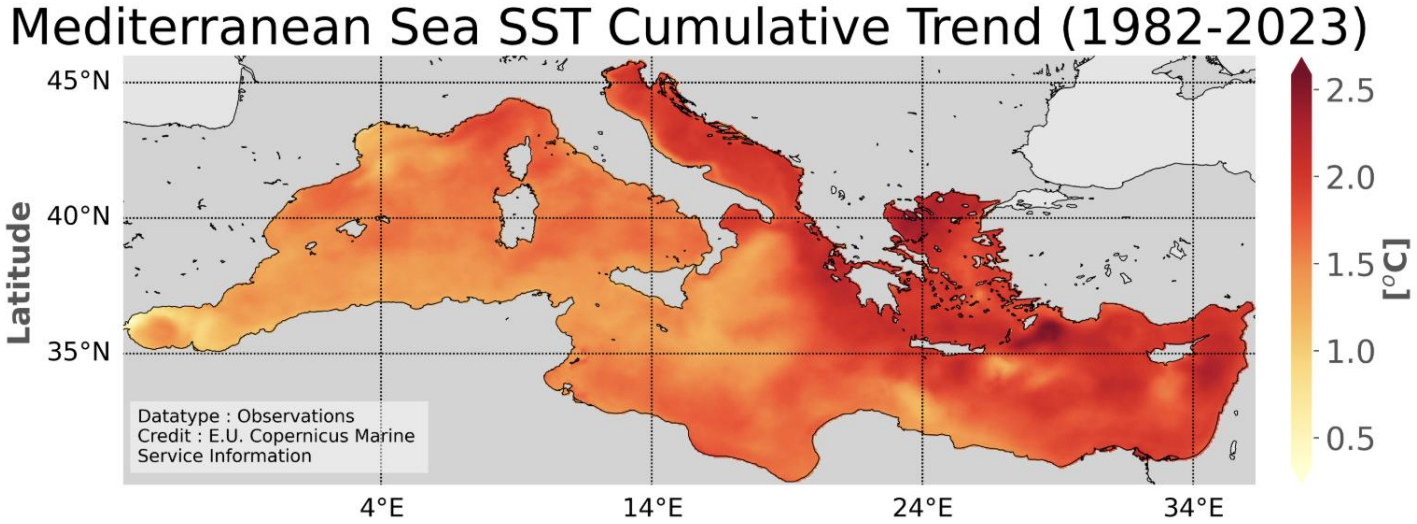
- taxonomic revision to interpret the impact of the population decline across the extent of the distributions.

Regional Case Study – The Mediterranean

Case study: The Mediterranean as a climate change hotspot



Mediterranean Sea Surface Temperature (SST)



Mediterranean SST warmed at a rate of 0.041 ± 0.001 °C per year

Mean surface temperature warming of 1.7 °C

Ref: EU Copernicus Marine Service Information (2024)

Mediterranean Marine Heat Waves

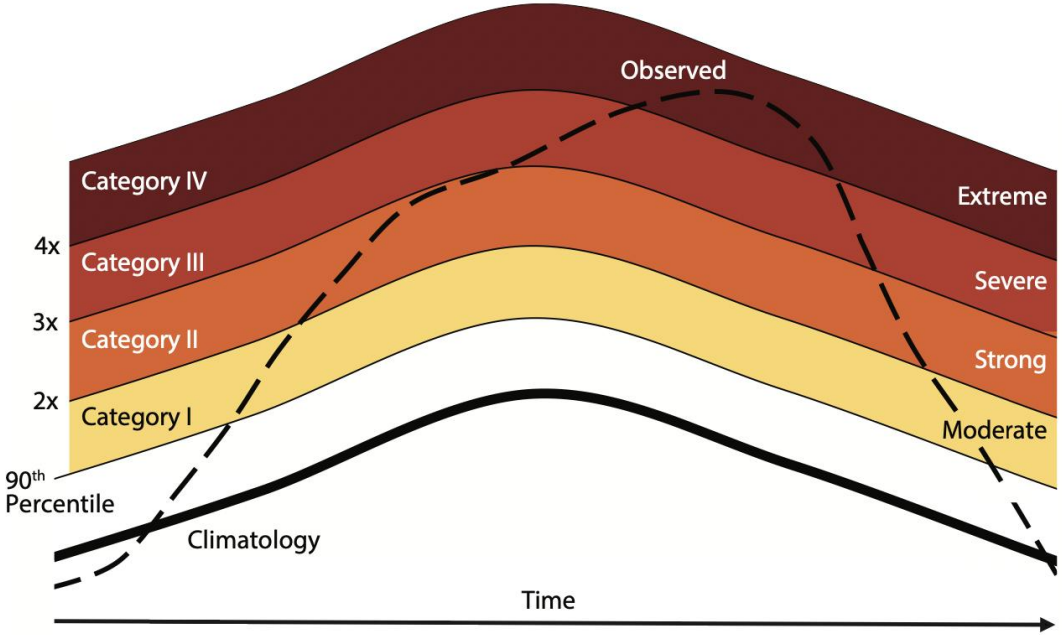


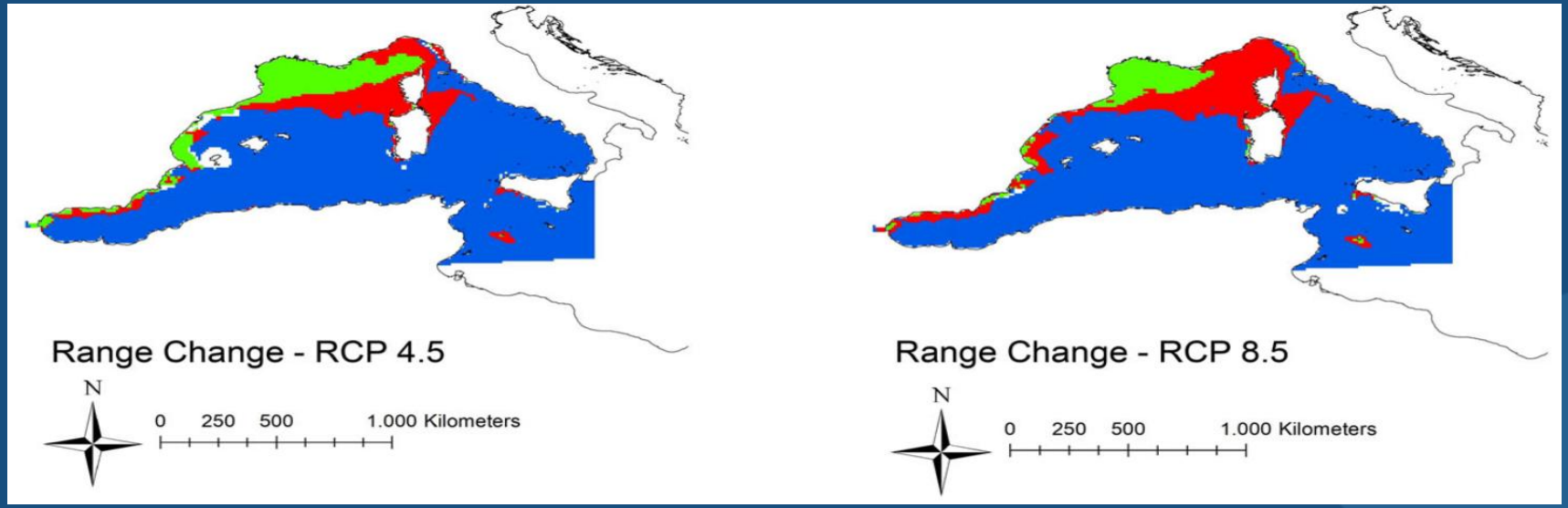
Figure from Hobday et al. (2018)

1982 – 2022 = 20 major events in the Mediterranean, 5 of which were extreme
(Martínez et al., 2023)

Fin whale range change

- Fin whale – range change scenarios between present & future scenarios
- Reduction of range between 55% and 70% & loss of suitable habitat in range of 57% to 71%

D'Amen et al., 2024



The case of the Northern Adriatic Sea


Adriatic Sea
GULF OF
TRIESTE
(north Adriatic)


Common bottlenose dolphin
Tursiops truncatus
MORIGENOS

MORIGENOS

Semi-enclosed

Shallow

Large variation in water temperature

Strong anthropogenic impacts


MORIGENOS


PREY
availability


Intra-specific
COMPETITION


Novel
PATHOGENS


THERMAL
stress
MORIGENOS

Cumulative effects

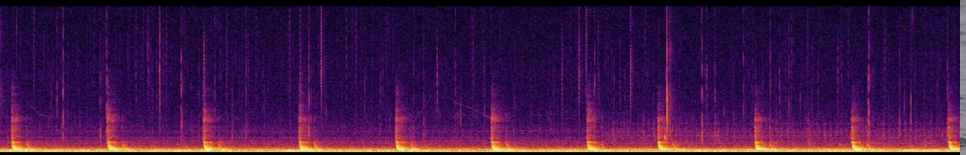
MORIGENOS


Prey
DEPLETION


Fisheries
BYCATCH


Fisheries
BYCATCH

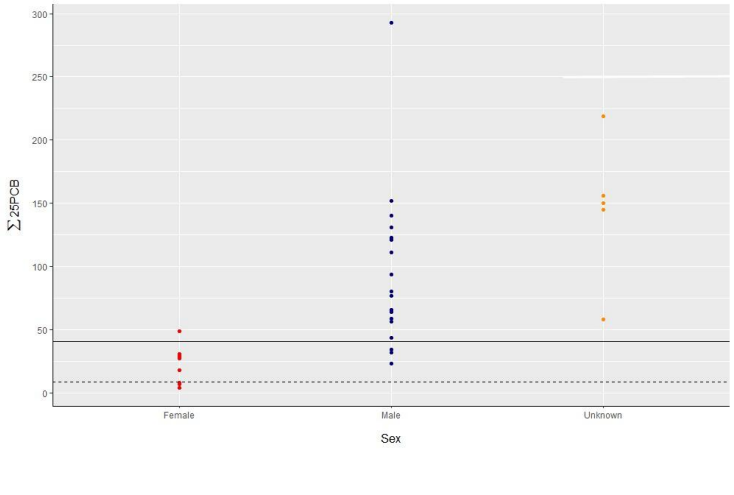

Gear
INGESTION
MORIGENOS



Underwater
NOISE

MORIGENOS


Chemical
POLLUTANTS


300
250
200
150
100
50
0
Σ25PCB
Female
Male
Unknown
Sex

MORIGENOS

Just add climate change...

Management implications and recommendations

IWC recommendations

IWC research recommendations:

1. Research to inform switch focus for management from **sustainability to building resilience**

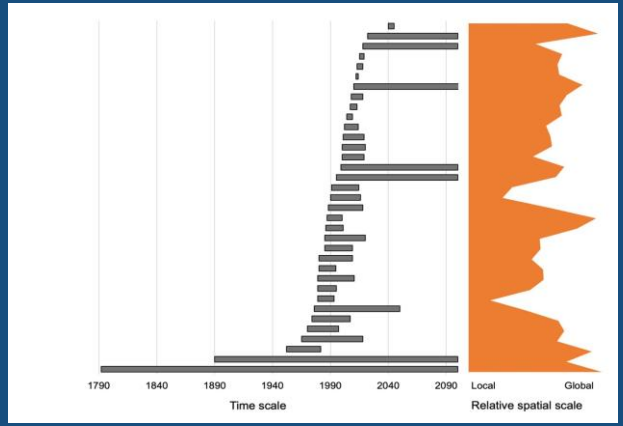
   Research to identify priorities, including: high impact stressors, regions under the greatest threat, vulnerability windows and at-risk populations or species
2. Work **on cumulative effects of multiple stressors** to support conservation and management

The 2021 workshop recommended that work on how climate change affects cetacean populations and species should:

- **Prioritise regions** known to be experiencing intense climate change impacts (esp. key habitats
- **Improve methods,** including developing best practice guidance for studies, and power analysis for detection of significant effects.
- Conduct analyses to **identify most significant vulnerabilities** for species/populations
- **Maximise survey effort** through additional partnerships to co-monitor species and environmental parameters.

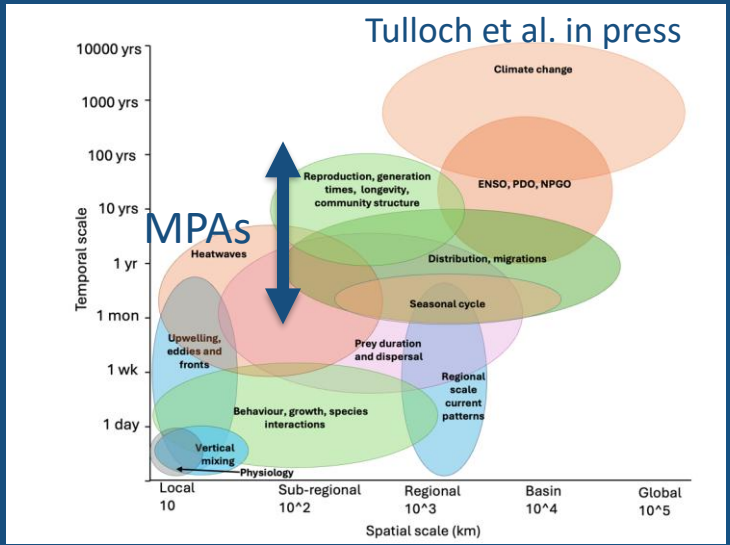
Matching Scales – Processes, Research, Actions

- Climate processes occurring at vast spatiotemporal scales
- Mismatches between physical vs ecological processes, vs research/management



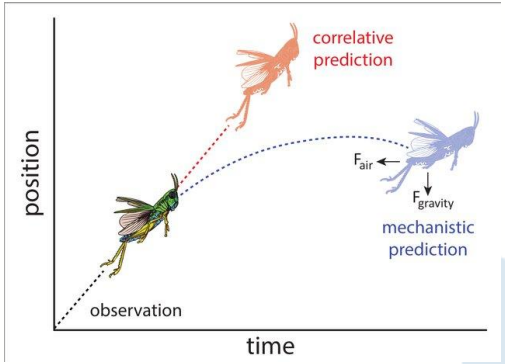
One solution: Long-term Population Studies: Prioritize research across larger temporal and spatial scales

- Scale up small scale studies to make wider inferences
- Transnational research and collaboration
- Capture processes and cause-effect relationships – requires **mechanistic studies**

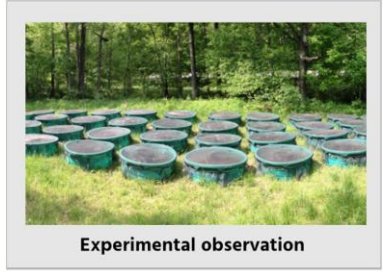


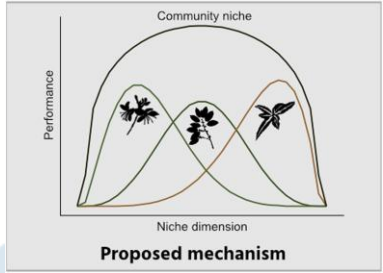
Research and Methodological Improvements

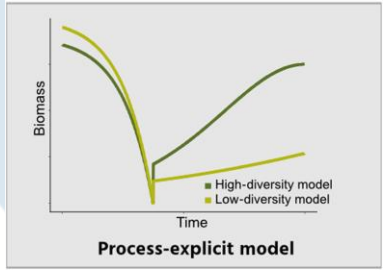
- **Predictive Process-Based Models:** Develop more mechanistic models that incorporate both environmental conditions and biological processes – ecosystem-based approaches
- **Integrated Approaches:** Combine multiple data sources including physiological data, environmental variables, and population dynamics
- **Comprehensive climate vulnerability assessments** for different baleen whale species
- **Climate Variables:** Include understudied factors like ocean acidification, sea-level rise, and extreme weather events



Maino et al. 2016







Pilowsky et al. 2022

Management Implications & Recommendations

- **Spatial Protection:** integrated transnational approaches that consider migration, protect critical feeding/breeding habitats
- **Dynamic Management:** Implement more rapid and adaptive management measures to address unexpected climate impacts
- **Multiple Stressors:** Address concurrent and cumulative threats including fishing gear entanglement, vessel strikes, noise pollution, and toxins
- **Ecosystem Approach:** Consider both direct climate impacts and indirect effects through prey availability and habitat changes to inform management
- **Ongoing research and monitoring**
- **International transboundary cooperation and collaboration**

Concluding Comments

Explaining Ocean Warming:

Causes, scale, effects and consequences

Edited by D. Laffoley and J. M. Baxter

September 2016

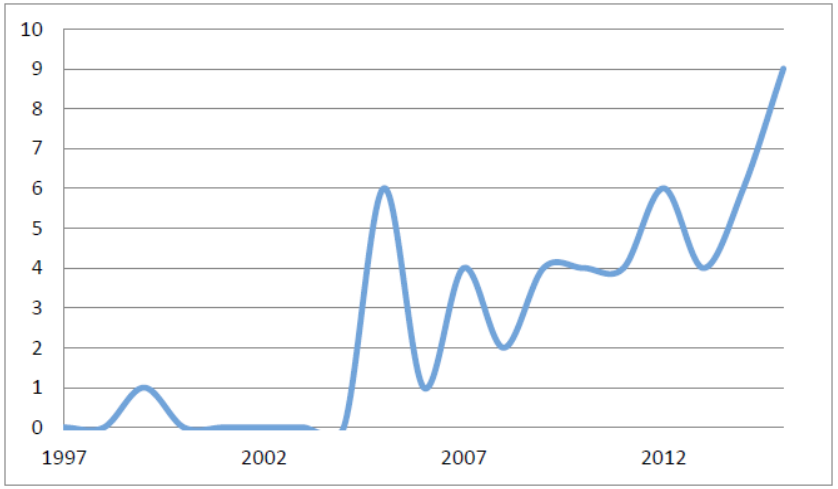


Figure 3.15.2 Number of scientific papers linking observed impacts to climate change in marine mammals 1997-2015 (N = 51).

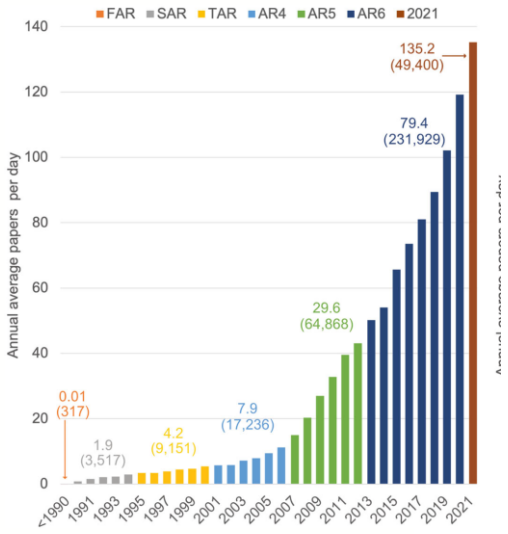
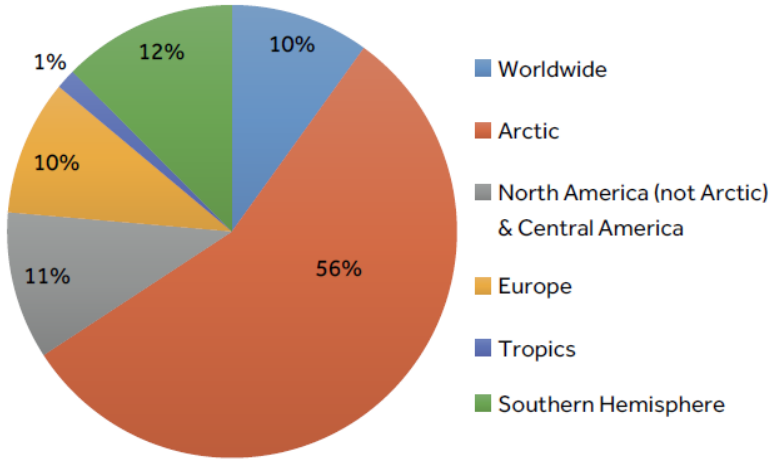


Figure 3.15.3 Regional representation of scientific papers published on marine mammals and climate change from 1997-2015, based on 352 papers drawn from database searches.



Ten years ago –

- Range expansions and contractions
- Changes in location and the nature of human activities
- New interactions with human activities
- Increased Eutrophication and toxic algal blooms
- Inundation and loss of viable breeding and other habitat
- Displacement of populations
- New competition between species

What has changed in the last decade?

Huge increase in published information – importance of long term monitoring apparent

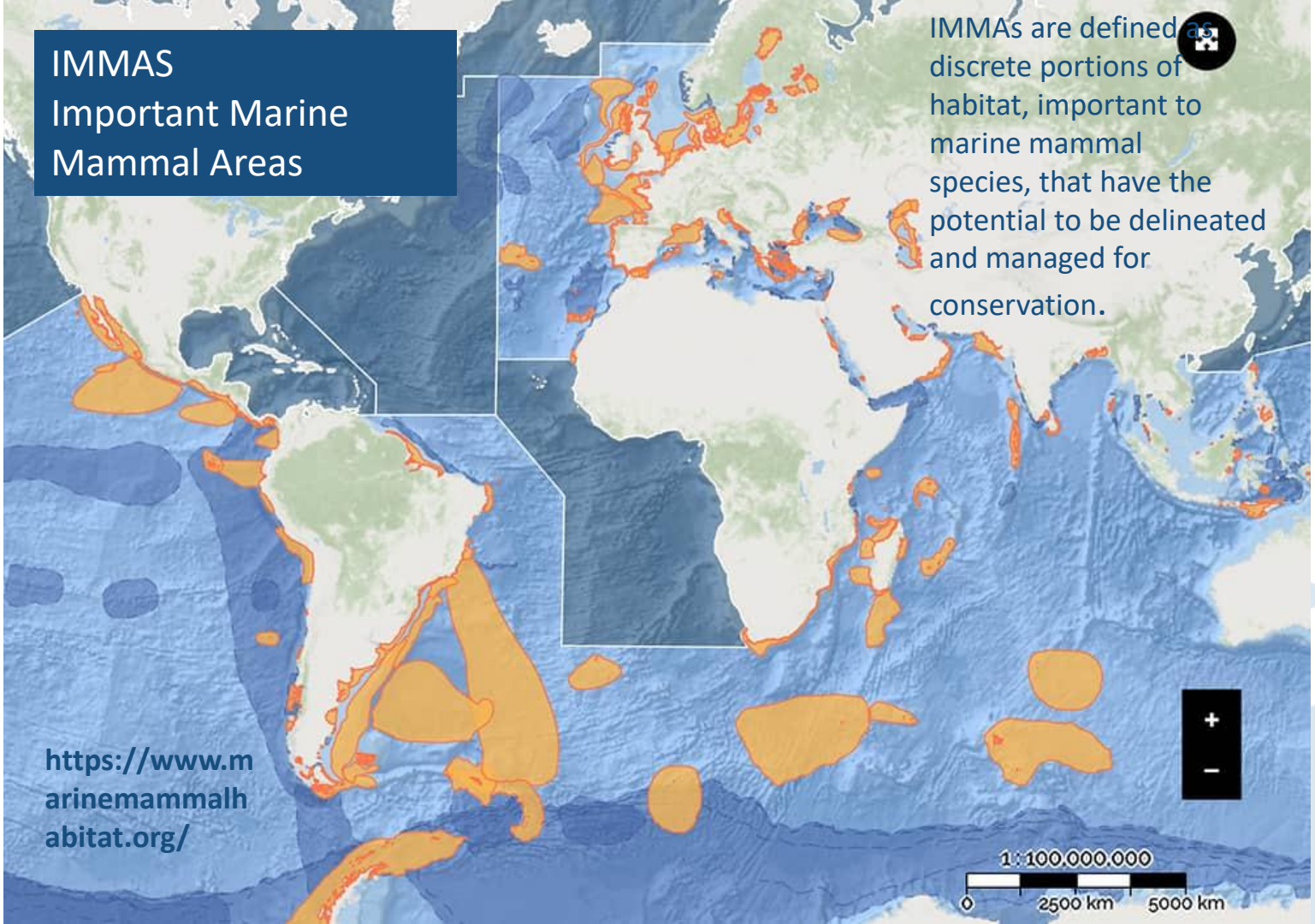
Clear climate-related concerns for some taxa – e.g. North Atlantic right whales

More concerns about changes to fluvial regimes and riverine and near-shore impacts

Threat from marine heat waves more in focus

Modelling is increasingly underpinned by evidence and changes are happening faster than predicted

New approaches needed to ensure conservation – action on threats that can be addressed more urgent – both site-related (e.g. IMMAs) and non-site-related e.g. bycatch, pollution, vessel strikes etc.


IMMAS
Important Marine
Mammal Areas
IMMAs are defined as discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation.
https://www.marinemammalhabitat.org/
1:100.000.000
0
2500 km
5000 km

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IWC Climate Change Workshop Reports: https://iwc.int/management-and-conservation/environment/climate-change

Thank you

INTERNATIONAL
WHALING COMMISSION

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