PROTECTING BLUE CORRIDORS

Challenges and solutions for migratory whales navigating national and international seas

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KEY MESSAGES

Protecting whales has benefits for nature and people

Growing evidence shows whales play a critical role in maintaining ocean health and our global climate, all while contributing to a global economy.

Blue corridors are critical ocean habitats for migratory marine species

Whales rely on critical ocean habitats – areas where they feed, mate, give birth, nurse young, socialise or migrate. “Blue corridors” are migration superhighways that allow marine megafauna to move between these critical habitat areas, and are essential for their survival.

Whales are an indicator of ocean health, but face growing threats

Entanglement in fishing gear (bycatch), climate change, ship strikes, and pollution (chemical, plastic and underwater noise) are impacting whales, their prey and their habitats. Whales face several of these threats simultaneously across their range, which are impacting recovery of populations and contributing to the decline in others.

We highlight a new conservation approach for enhanced cooperation

Threats to whales have evolved; our conservation approach must evolve too. From local to regional to international levels, science, civil society, industry, states and intergovernmental bodies have a role in safeguarding whales and their migrations, mitigating threats and co-designing solutions.

We need to act now

Six out of the 13 great whale species are classified as Endangered or Vulnerable, even after decades of protection. Some may go extinct within our lifetimes – unless we act now.

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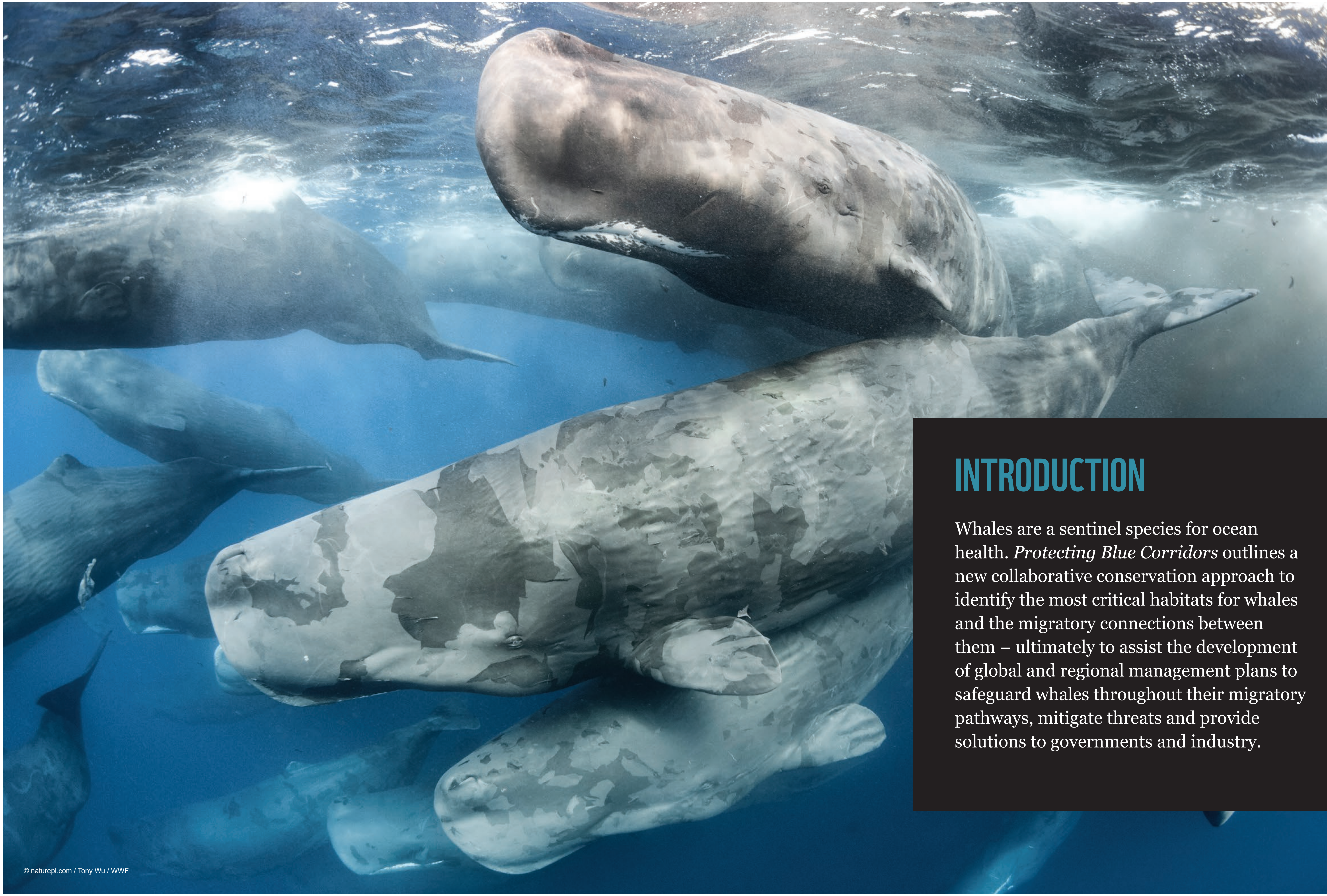
ABBREVIATIONS AND ACRONYMS

ABNJ	Areas Beyond National Jurisdiction (including both the High Seas and the seabed Area)
ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
AIS	Automatic identification system
ALDFG	Abandoned, lost or discarded fishing gear
APMs	Associated protective measures
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BBNJ	Biodiversity Beyond National Jurisdiction
CBD	Convention on Biological Diversity
CCAD	Central American Commission for Environment and Development
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMAR	Eastern Tropical Pacific Marine Corridor
CMS	Convention on the Conservation of Migratory Species of Wild Animals
COP	Conference of the Parties
CPPS	Permanent Commission of the South Pacific
DOM	Dynamic ocean management
EBSA	Ecologically or biologically significant area
EEZ	Exclusive economic zone
FAO	Food and Agricultural Organization
GES	Good environmental status
GGGI	Global Ghost Gear Initiative
IATTC	Inter-American Tropical Tuna Commission
ICRW	International Convention for the Regulation of Whaling
IMMA	Important marine mammal area
IMO	International Maritime Organization
INGO	International non-government organization
IOTC	Indian Ocean Tuna Commission
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
KBA	Key biodiversity area
MEPC	Marine Environment Protection Committee
MPA	Marine protected area
MSP	Marine spatial planning
NOAA	National Oceanic and Atmospheric Administration
OECM	Other Effective Area-based Conservation Measures
PARCA	Environmental Plan for the Central American Region
PSSA	Particularly sensitive sea area
RFMO	Regional fisheries management organization
SPRFMO	South Pacific Regional Fisheries Management Organization
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate Change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INTRODUCTION

Whales are a sentinel species for ocean health. *Protecting Blue Corridors* outlines a new collaborative conservation approach to identify the most critical habitats for whales and the migratory connections between them – ultimately to assist the development of global and regional management plans to safeguard whales throughout their migratory pathways, mitigate threats and provide solutions to governments and industry.

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Cetaceans (whales, dolphins and porpoises) rely on different critical ocean habitats – areas where they feed, mate, give birth, nurse young, socialise or migrate – for their survival.[1] In their simplest and narrowest sense, "blue corridors" are migration superhighways for marine megafauna such as whales. More broadly, the term encompasses the idea that marine megafauna move among different but ecologically interconnected areas, and that movement between critical habitats are essential to their survival.

Drawing on the latest scientific evidence from years of satellite tracking data and knowledge from the global research community, this report details the work of WWF, its partners – including University of California Santa Cruz and Oregon State University – and many data contributors to map routes of migratory whales as they move through international waters, national seas and coastal areas, between key breeding and foraging locations. Areas covered in the report include the eastern Pacific Ocean, Indian Ocean, Southern Ocean, Mediterranean Sea and southwest and north Atlantic Ocean. Importantly, information gathered for these areas attempts to identify where migratory routes and key areas overlap with a range of emerging and cumulative threats from human activities.

A sentinel species for ocean health

Whales are some of the ocean's most inspiring, iconic marine species. Scientific evidence gathered over the past decade bears this out, showing that whales play an essential role in the overall health of our oceans and, by extension, the whole planet.[2,3]

Growing evidence shows that whales help to regulate the climate by capturing carbon throughout their lifetime – one whale captures the same amount of carbon as thousands of trees – but their excrement also fertilizes our oceans, which in turn fuels phytoplankton, microscopic plants that produce more than half of the world's oxygen.[2] This contribution to ocean productivity has benefits for nature, for people and their livelihoods, and for major global industries. Whales contribute to maintaining the food web of the commercial fishing industry, for example, which is valued at more than US$150 billion.[2]

Economists have sought to quantify the numerous benefits whales offer in dollars and cents to give further weight to whales' extrinsic value. The International Monetary Fund estimates the value of a single great whale at more than US$2 million, which totals more than US$1 trillion for the current global population of great whales. The global whale-watching industry alone is valued at more than US$2 billion annually.[2]

Whales have intrinsic value, and our oceans need thriving populations. The benefits they provide – from capturing carbon to enhancing marine productivity – only strengthen the case for protecting them.[3]

Extinction risk "real and imminent"

If healthy whale populations are an indicator of overall marine ecosystem health, there is growing concern. A third of the world's cetaceans are now classified by the International Union for Conservation of Nature (IUCN) as Threatened, meaning they have either a high, very high or extremely high risk of extinction in the wild. Six out of the 13 great whale species are classified as Endangered or Vulnerable, even after decades of protection after commercial whaling.[4] The extinction risk to cetaceans is "real and imminent" according to more than 350 scientists and conservationists – WWF experts among them – who signed an open letter in 2020 calling for global action to protect cetaceans from extinction.[5] More than half of all species are of conservation concern.

In 2020, the IUCN listed the North Atlantic right whale as Critically Endangered. In 2021, experts released a new population estimate, raising alarm that the iconic species is at the lowest point in about 20 years, numbering only 366 individuals – a decline of 30 per cent over the past 10 years.[6]

They join species such as the critically endangered vaquita porpoise, only found in the upper Gulf of California, Mexico; the species sits poised on the verge of extinction, with an estimated population size that may be as low as 10 individuals. In New Zealand, Māui dolphins are also in urgent need of complete threat removal to enable their recovery, with only about 60 individuals remaining.

Threats to whales are increasing

In countless areas around the globe, cetaceans are under threat from human activities. An estimated 300,000 cetaceans are killed each year as a result of entanglement in fishing gear and ghost net,[7] while populations are impacted from overfishing, increasing ship traffic,[8,9] underwater noise,[10] pollution,[11,12] offshore development, and climate change.[13]

These threats are often occurring in concert and overlap with whales' critical habitats and migration routes, working to create a hazardous and at times fatal obstacle course for whales travelling between breeding and foraging areas. For example, between 2017 and 2021, 34 North Atlantic right whales died off the Canadian and United States coasts from ship strikes and entanglement in fishing gear.[14] Just one death jeopardizes this population's survival. As this report emphasizes, it is not just one threat that is causing significant decline in whale populations (as well as the health of remaining individuals), it is many threats, working together, that are causing cumulative and often deadly impacts.

During the 20th century, nearly 3 million whales were commercially harvested, driving many species to the brink of extinction.[15] While a significant reduction of commercial whaling has allowed some populations to bounce back, new threats have emerged[16,17] that are making the migratory routes of whales and other marine species increasingly difficult and dangerous to navigate. As the threats to whales evolve, our conservation approach must evolve with them across their entire range.

Marine connectivity conservation for whales

This report draws on a conservation practice already widely used on land, known as "connectivity conservation", but applies it to the world's seas and through a singular focus on whales, which are considered "umbrella species" – that is, representatives of the biodiversity of the complex ecosystems they inhabit. Put simply, this means conserving whales across their entire range will also help many other species.[1]

Connectivity conservation is a concept that recognizes that species survive and adapt better when their habitats are managed and protected as large, interconnected networks. Marine protected areas (MPAs) are conservation tools intended to protect biodiversity, promote healthy and resilient marine ecosystems, and provide societal benefits.[18]

The IUCN World Commission on Protected Areas Connectivity Conservation Specialist Group and Marine Connectivity Working Group, of which WWF experts are members, define connectivity conservation as the action of individuals, communities, institutions and businesses to maintain, enhance and restore ecological flows, species movement and dynamic processes across intact and fragmented environments. In essence, this is what our report seeks to achieve, and in applying these lessons learned on land to our seas, protect migratory whales into the future.

Protecting blue corridors for whales requires a holistic strategy, one that engages multiple international and regional organizations responsible for formulating policies across a range of areas and industries, from fisheries to shipping, among them the International Whaling Commission, the International Maritime Organization and regional fisheries management organizations, and international conservation agreements such as the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Engagement with the United Nations (UN) is particularly critical at this time, given its current negotiations over a new treaty for the high seas.[19] The high seas make up two thirds of the Earth's oceans, yet no overarching treaty exists to conserve vulnerable species and ecosystems in these waters. Today, only about 7.91 per cent of the world's oceans are protected in actively managed MPAs. WWF, the scientific community and over 75 governments have all now backed a call to protect 30% of our ocean by 2030 through implementing networks of marine protected areas or other effective area based conservation measures (OECMs).[20,21] This is commonly known as the 30x30 pledge.[22,23]

Mapping the groundwork for urgent action

This report lays the groundwork for engagement with policymakers from all these organizations by synthesizing the latest science and data specific to each of their policy areas – to date largely occurring independently of each other – and bringing this information together for the first time in one view.

Drawing on the latest scientific data from years of satellite tracking effort and knowledge from the global research community, this report details the work of many research groups to map routes of migratory whales as they move through international waters, national seas and coastal areas, between key breeding and foraging locations. Importantly, the information gathered presents an illustrative snapshot of migratory routes and key ocean areas that overlap with a range of emerging and cumulative threats from human activities. There is still much more to discover about migration of many whale populations.

Our goal is for policymakers to see this bigger picture and armed with this knowledge, work together to formulate complementary policies for cumulative benefit. To help inform this work, the report identifies key conservation opportunities globally and some innovative solutions available to governments, policymakers and industry to safeguard whales, their migrations and their critical habitats for future generations.

In terms of their execution, we require a suite of responses to tackle the multiple threats, from reducing bycatch and shipping impacts in key hotspots to establishing networks of MPAs. As some whales' migration span across ocean basins, networks of protected areas will need to be large and potentially mobile where boundaries shift across space and time, as climate change impacts dynamic habitats and causes shifts in species range.[24]

As for when this collective work needs to be done, the answer is now. The open letter from cetacean scientists worldwide[4] states: "The lack of concrete action to address threats adversely affecting cetaceans in our increasingly busy, polluted, over-exploited and human-dominated seas and major river systems, means that many, one after another, will likely be declared extinct within our lifetimes … Whales, dolphins and porpoises are seen and enjoyed all over the world, and are valued as sentient, intelligent, social and inspiring species; we should not deny future generations the opportunity to experience them."[4]

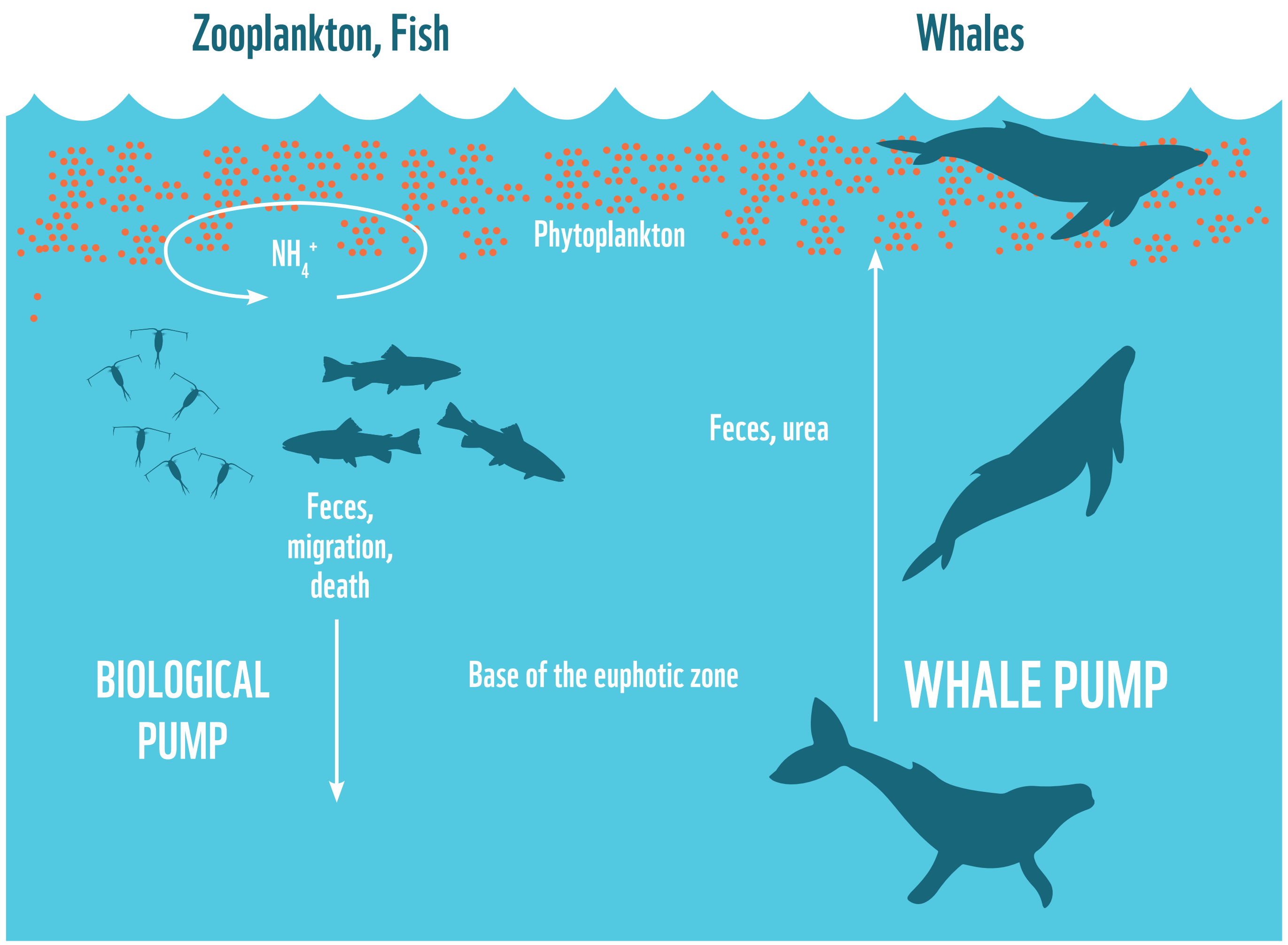
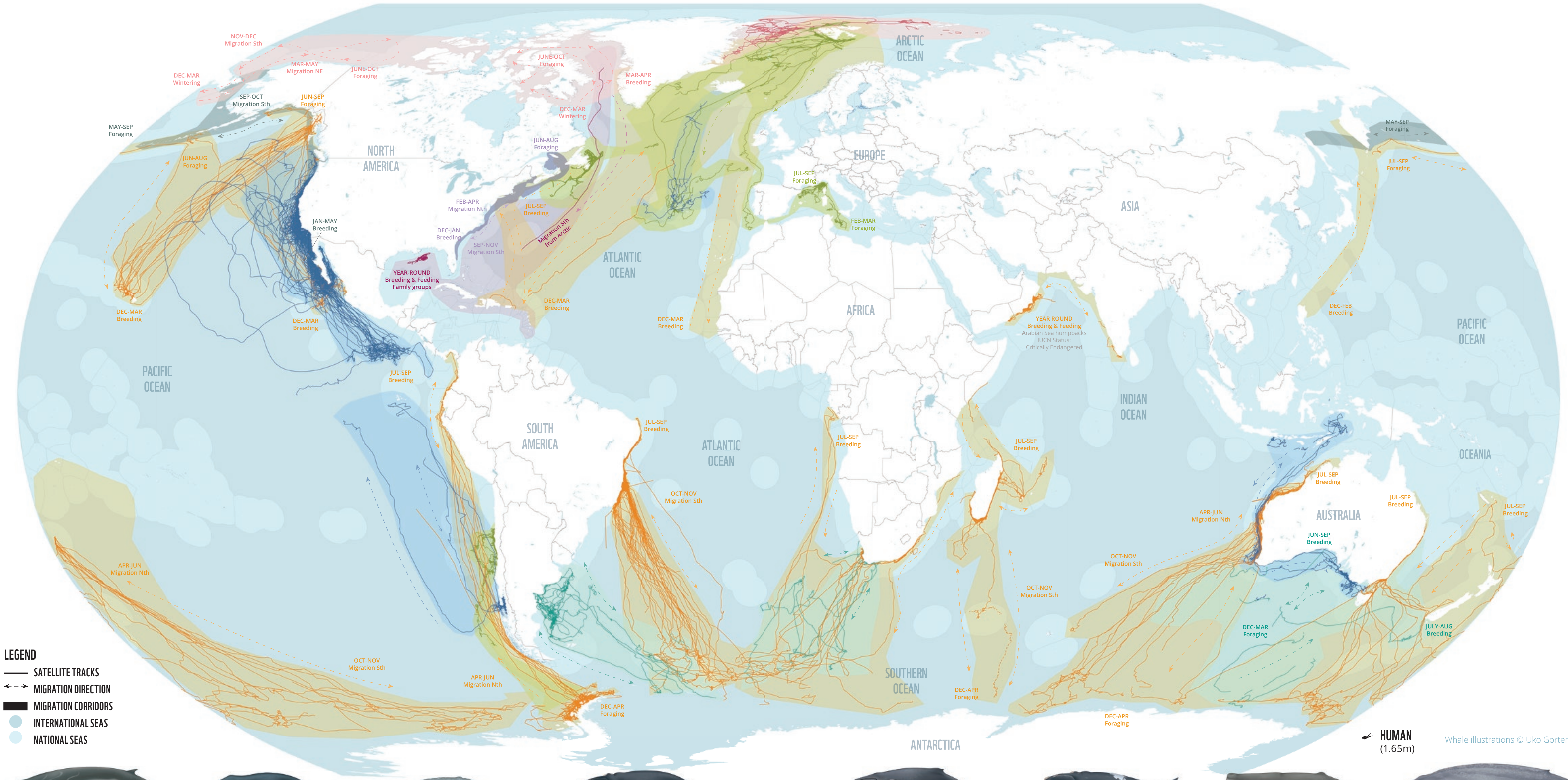


Figure 1: An illustration of the "whale pump", where whales release nutrients such as iron, carbon, nitrogen and sulphur from deep, nutrient-rich waters in shallower waters via feeding and excretion.[25]

WHALE SUPERHIGHWAYS

Whales move across ocean basins as they travel between feeding and breeding areas, in and out of international and national waters. Some migrations are seasonal, some are year-round.

For the first time, we present a global view of blue corridors for whales, combining satellite tracking data from over 1000 tags. They help uncover the migration patterns of whales and the locations and characteristics of their critical habitats.



Whale illustrations © Uko Gorter

FIN WHALES
(Balaenoptera physalus)
IUCN Status: Vulnerable
Length: 17-20m
Population: ~100,000

BOWHEAD WHALES
(Balaena mysticetus)
IUCN Status: Least concern
Length: 13-15m
Population: ~10,000

GRAY WHALES
(Eschrichtius robustus)
IUCN Status: Least concern
Length: 12-14m
Population: ~27,000

NORTH ATLANTIC RIGHT WHALES
(Eubalaena glacialis)
IUCN Status: Critically Endangered
Length: 13-16m
Population: ~350

HUMPBACK WHALES
(Megaptera novaeangliae)
IUCN Status: Least concern
Length: 13-16m
Population: ~84,000

SOUTHERN RIGHT WHALES
(Eubalaena australis)
IUCN Status: Least concern
Length: 15-18m
Population: ~13,600

SPERM WHALES
(Macrocephalus physeter)
IUCN Status: Vulnerable
Length: 11-20m
Population: ~350,000

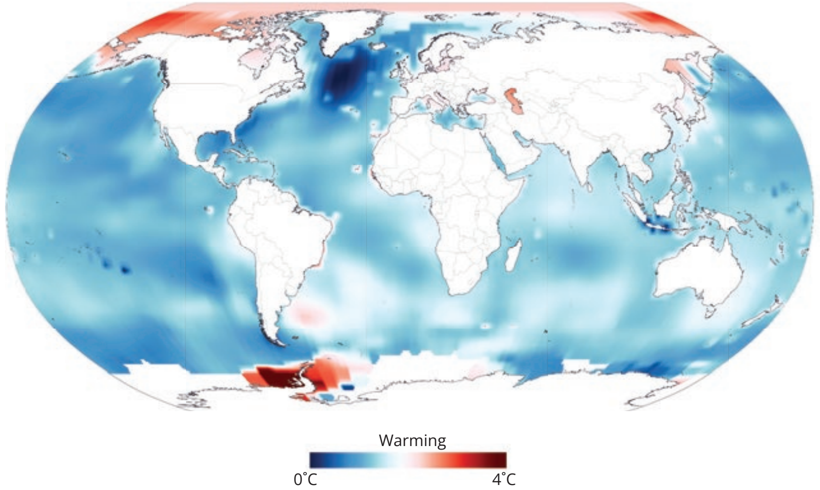
BLUE WHALES
(Balaenoptera musculus)
IUCN Status: Endangered
Length: 24-26m
Population: ~5,000–15,000

MIGRATIONS ARE BECOMING INCREASINGLY DANGEROUS

Multiple human threats are impacting whales within both critical habitats and along their migration corridors.[16,17]

CLIMATE CHANGE

Climate change affects prey abundance, distribution and type. Ocean warming changes the timing of important life events including migration. Ice melt causes decline in critical habitat and provides less protection from predators.

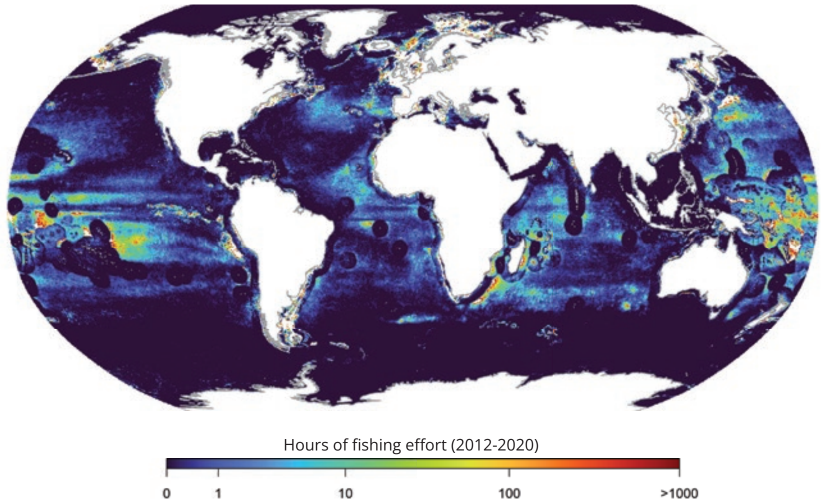


FISHERIES

BYCATCH
Entanglement in fishing gear is the most significant threat to the survival of whale and dolphin populations globally.

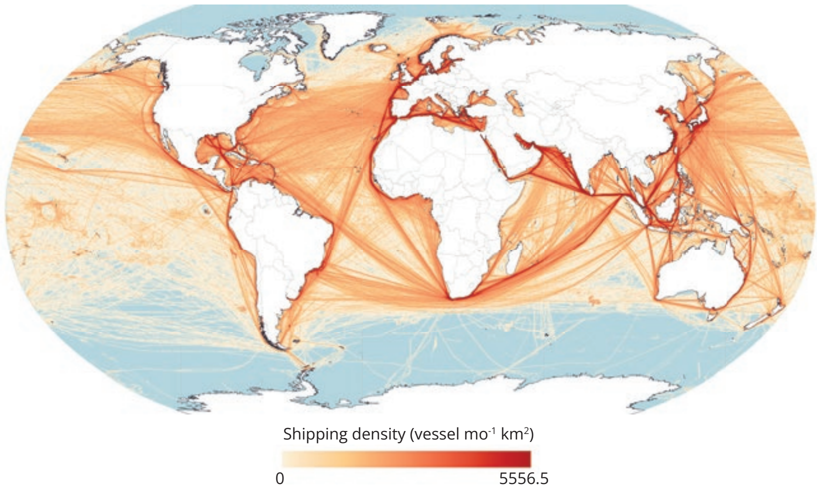
GHOST NETS
Discarded, lost, or abandoned fishing gear in the marine environment is also a risk. This gear continues to entangle marine species, smother habitat, and act as a hazard to navigation.

OVERFISHING
Reduction of prey availability due to overfishing threatens all cetaceans.



SHIPPING AND VESSEL STRIKES

Shipping poses multiple threats, including deaths caused by vessel strikes in areas where there is high vessel traffic in important ocean habitats.



POLLUTION

CHEMICAL
Introduced synthetic chemicals in the sea bioaccumulate in the marine food chain leading to toxic levels in top predators like whales.

PLASTIC
Toothed whales such as sperm whales ingest plastics, confusing them with prey. Baleen whales ingest plastic indirectly where their prey contains microplastics.

UNDERWATER NOISE
The introduction of noise into the ocean from shipping, seismic survey, industrial operation, construction and military sonar interferes with the ability of whales and other noise-sensitive species to carry out many life functions. Underwater noise can result in disturbance, displacement, temporary hearing loss, permanent hearing damage and direct mortality.

OFFSHORE EXPLORATION, MINERAL EXPLOITATION AND COASTAL DEVELOPMENT

OIL AND GAS
Oil and gas exploration and extraction disturbs whales and their prey through underwater noise pollution, construction of supporting infrastructure, oil leaks, associated shipping and the potential for large, catastrophic oil spills.

CONSTRUCTION
Potential impacts on whales include habitat change, habitat loss, degradation and fragmentation, displacement or injury on account of construction and operational noise.

SEABED MINING
There is growing interest in exploiting mineral deposits from the area of the ocean below 200 m which covers about 65% of the Earth's surface. This emerging threat could affect whales and their prey through disturbance of the seafloor, sediment plumes and pollution.

WHALING

COMMERCIAL WHALING
Nations including Japan and Norway continue to kill whales for commercial purposes.

HUNTING OF SMALL CETACEANS FOR FISHERIES BAIT
Hunting of small cetaceans – for live capture, food, bait and other products – is ongoing in many parts of the world and some of it is unsustainable and unregulated.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NAVIGATING BLUE CORRIDORS – THE THREATS

Whales face increasing threats due to human activities in their critical habitats and migratory corridors across their entire range.[16,17] Populations are affected by increasing ship traffic and noise pollution. Climate change and chemical and plastic pollution are impacting their habitats and prey. Meanwhile, an estimated 300,000 whales, dolphins and porpoises are killed each year as a result of fisheries bycatch – entanglement in fishing gear and nets.

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Fisheries

Bycatch – entanglement in fishing gear – is recognized as the most significant threat to the survival of cetacean species and populations globally.[7,17]

Many international non-government organizations, intergovernmental organizations and national regulatory bodies realise that addressing the threat of bycatch is one of the most pressing cetacean conservation challenges of the 21st century. Bycatch of cetaceans occurs in all kinds of fishing operations, from large industrial to localised artisanal fisheries. It also occurs in most types of fishing gear. Driftnets, gillnets and entangling nets are known to cause the highest amount of cetacean bycatch. Large whales are particularly susceptible to becoming entangled in nets and ropes associated with pots and traps and fish aggregating devices, which are used to attract fish.[27]

The International Whaling Commission (IWC) launched the Bycatch Mitigation Initiative to develop, assess and promote effective bycatch prevention and mitigation measures worldwide.[27] In European countries bordering the North Atlantic and the Mediterranean Sea, ACCOBAMS and ASCOBANS have created a joint working group on bycatch. Similarly, the Food and Agricultural Organization (FAO) has several subsidiary bodies, such as the Committee on Fisheries and Indian Ocean Tuna Commission, that are recognizing the importance of addressing fisheries bycatch.

There is also growing awareness of the lack of effective monitoring of fishing activities at sea, which means that we know little about the true impact that fisheries have on ocean wildlife such as cetaceans. Meanwhile, technology is moving swiftly to the point of being able to deliver cost-effective, real-time coverage of fishing activities at sea, and there is a real opportunity for Remote Electronic Monitoring of our fisheries activities. That way we better understand more about what target fish species are being caught and what species are accidentally caught in fishing gear. This move will help improve the sustainability of fishing and help bring an end to wildlife bycatch on large and small vessels.[28]

Each year, 640,000 tonnes of fishing gear are left in our oceans. Abandoned, lost or discarded fishing gear (ALDFG) – commonly called "ghost gear"[29] – accounts for a minimum of 10 per cent of all marine litter entering the oceans.[30] That's more than one tonne of fishing gear lost in the sea for every minute of the year. This type of litter can persist in the marine environment for up to 600 years, continuing to catch and kill marine life before eventually breaking down into microplastics and ending up in the food chain.

A recent study estimates that 5.7 per cent of all fishing nets, 8.6 per cent of all traps and 29 per cent of all lines are lost around the world each year.[31] The Great Pacific Garbage Patch is a major ocean plastic accumulation zone in the subtropical waters between California and Hawaii. At least 46 per cent of it consists of fishing gear.[32] The effect that ghost gear entanglement has on marine megafauna, namely marine mammals, turtles, sharks and rays is significant: a total of 76 publications highlight that more than 5,400 individuals from 40 different species were recorded as entangled in, or associated with, ghost gear.[33]

Ship strikes

The ever-expanding shipping traffic from super-tankers and cargo vessels in whales' breeding grounds and along their migration routes results in an increased risk of ship strikes. Some of the busiest ports and channels in the world's oceans overlap with important habitats for whales.[34]

Globally, shipping poses multiple threats to whales, including deaths directly caused by vessel strikes.[9,35] Ship strikes are one of the leading causes of human-induced mortality for several whale populations around the globe, including many that are already threatened or endangered after decades of whaling.[9,36,37] Between 1992 and 2012, global ship traffic increased fourfold[38] and it is projected to increase 240–1,209 per cent by 2050.[10,39]

Climate change impacts on whales and their prey

Marine ecosystems are being severely impacted by climate change.[40,41] Marine mammals have unique ecologies with complex life cycles that make predicting their responses to climate change more difficult and, for some species, make them especially vulnerable to climate change impacts.[42] Broadly, climate change affects the phenology (the timing of recurring biological events, such as migration), demography (aspects such as survival rates and calving rates) and distribution of marine vertebrates,[43] which can influence marine ecosystem structure and functioning. Shifting geographic ranges of marine species have been observed across all ocean regions.[41]

Changes in the distribution and abundance of marine mammals' prey is a central way in which climate change impacts whales. However, how climate change impacts the individual physiology of whales is still poorly understood.[42] Whales also may be affected by physical changes to their habitats and increased susceptibility to disease and contaminants.[44]

Arctic and Antarctic cetaceans are thought to be especially sensitive to climate change because many of them rely on sea ice and sea ice ecosystems.[45,46] The rapid decline of sea ice in the Arctic is altering habitat availability, shelter from predators and timing of important life events for endemic whales. This includes their seasonal migrations, which for narwhal (*Monodon monoceros*), bowhead (*Balaena mysticetus*) and beluga (*Delphinapterus leucas*) whales, follows sea ice retreat in spring/summer and advance in autumn/winter.[47–49] Increasing frequency of marine heatwaves in the Pacific Arctic as a result of climate change may also be responsible for bowhead whales in this region foregoing their seasonal migration south and remaining in their summer feeding grounds over winter for the first time in 2018–19.[50,51] This possibly represents a major shift in migration behaviour for these whales as a result of climate change.

In the Southern Ocean, there are regional, southward shifts in Antarctic krill distribution due to ocean warming.[52] For whales feeding almost exclusively on krill – such as Antarctic blue (*Balaenoptera musculus intermedia*), humpback (*Megaptera novaeangliae*) and Antarctic minke whales (*Balaenoptera bonaerensis*) – it is likely to impose high energetic costs on migration, with effects on body condition, reproductive fitness and population abundance.[53] In particular, the distribution and ecology of Antarctic minke whales are directly tied to sea ice[54] where any changes that affect the quantity and quality of their habitat and food availability could be significant.[55]

Climate change will impact cetaceans in other regions too.[13] Particularly concerning is the possibility that multiple stressors will act in concert and magnify the impact of climate change long term.[56]

Chemical, plastic and underwater noise pollution

Many different substances to which marine mammals are exposed may adversely affect their health. These include natural elements that become more concentrated due to human activities, synthetic chemical compounds, oil-pollution-derived substances, marine debris, sewage-related pathogens, excessive nutrients causing environmental changes and radionuclides.[57] Although there is broad awareness of the threat of pollution to marine mammals, the long-term impact of pollution on marine mammal health is difficult to study and not well-known.[57]

Chemical pollutants include persistent organic pollutants, heavy metals, and pharmaceuticals and personal-care products.[58] Marine mammals are especially vulnerable to such pollutants because they often occur in polluted coastal waters, are long-lived and therefore accumulate pollutants over time, occupy high trophic levels and thus biomagnify pollutants, and cannot metabolically eliminate persistent chemicals.[59,60]

Marine anthropogenic debris, in particular synthetic materials, affects marine mammals. Individuals can die or be negatively impacted by entanglement in or the ingestion of plastic litter. Published records indicate that currently 66 per cent of marine mammal species have been affected – 41 per cent by entanglement and 50 per cent by ingestion[61] – but likely every species will eventually be affected. Entanglement is often lethal, but in most cases it is impossible to distinguish between entanglement in active gears (mostly fishing) or in true debris. Similarly, examples exist for lethal ingestion of debris, such as 7.6kg of plastic debris causing stomach rupture in a sperm whale (*Physeter macrocephalus*).[62] However, in many situations, debris found in stomachs does not provide firm evidence that it caused death and sub-lethal impacts are hard to quantify.[57] This example is concerning as sperm whales feed at depths up to 1,000 metres.[63]

It is often unclear why marine mammals ingest debris. Contrary to what might be expected, ingestion of debris in the filter-feeding baleen whales (54 per cent) appears less common than in the more target-hunting toothed whales (62 per cent). Within species, the frequency of non-lethal ingestion of plastic debris is often poorly known, as sample sizes are usually small and research methods do not focus on detecting debris in stomach contents.[64] Nevertheless, ingestion rates of up to 35 per cent for individuals have been recorded for estuarine dolphins[65] and up to 12 per cent in harbour seals.[66] Unavoidably, all marine mammals will ingest microplastics, partly because marine mammals' prey species ingest them at significant rates.[67]

Microplastics have been found in the gut of humpback whales[68] while their baleen can accumulate small plastic particles.[69] Negative physical and chemical impacts from microplastic ingestion have been shown experimentally to occur at lower trophic levels. Impacts in natural situations and at higher food web levels are not known, but may occur as some plastic additives have endocrine disrupting properties.[70] Effects of nanosized synthetic particles are even more unclear, but of concern as such particles may permeate cell membranes affecting cellular functions through physical or chemical interactions.[71]

Underwater noise pollution is of growing global concern because of its impacts on a wide range of marine species, including whales, sea turtles and fish.[35,72] Whales in particular have evolved to use sound as their primary sense, and depending on the source, underwater noise can have a range of impacts on individuals and populations.[10]

Shipping is the leading contributor to ocean noise pollution worldwide[35] and in some parts of the ocean, underwater noise levels have doubled each decade since the 1960s.[34,35,73] Ship noise is characterized as continuous and generally low in frequency, although it can extend to high frequencies.[74] Most noise is incidentally caused by propeller cavitation: the formation and implosion of small bubbles against propellers as they rotate. Hull vibration and engine noise also contribute to a ship's acoustic footprint. Other sources of underwater noise range in frequency from low to high and can be high in their intensity. They include explosions, sonar, underwater construction and seismic survey.

Vessel noise has been shown to disrupt communication and feeding behaviour and cause displacement of whales from important habitats,[35] which can impact health and reproduction and lead to population declines. High-intensity sources of underwater noise can result in direct impacts through acute injury (temporary or permanent hearing damage) or death.[74–77]

Offshore exploration and coastal development

Industrial activities include land reclamation, the construction of infrastructure such as ports as well as facilities related to aquaculture, energy production and military activity. Potential impacts on whales include habitat loss, degradation or fragmentation as well as displacement or injury on account of construction and operational noise.[17]

Offshore oil and gas infrastructure such as pipelines and platforms have proliferated along continental margins and in the deeper oceans worldwide.[78] Oil and gas exploration and extraction can disturb whales and their prey through underwater noise pollution, construction of supporting infrastructure, oil leaks, associated shipping and the potential for large, catastrophic oil spills.

The ocean below 200m depths is referred to as the deep-sea and is the largest biome on our planet, with much of its diverse life unmapped. Parts of the deep seabed also contain mineral deposits. Interest in deep seabed mining to extract minerals several kilometres below the surface is increasing. Until there is enough knowledge about the life and functions of the deep sea, diverse voices are calling for a moratorium on this emerging practice.[79] Seabed mining could affect whales and their prey through disturbance of the seafloor, sediment plumes, noise and pollution.[80]

Whaling

Commercial whaling

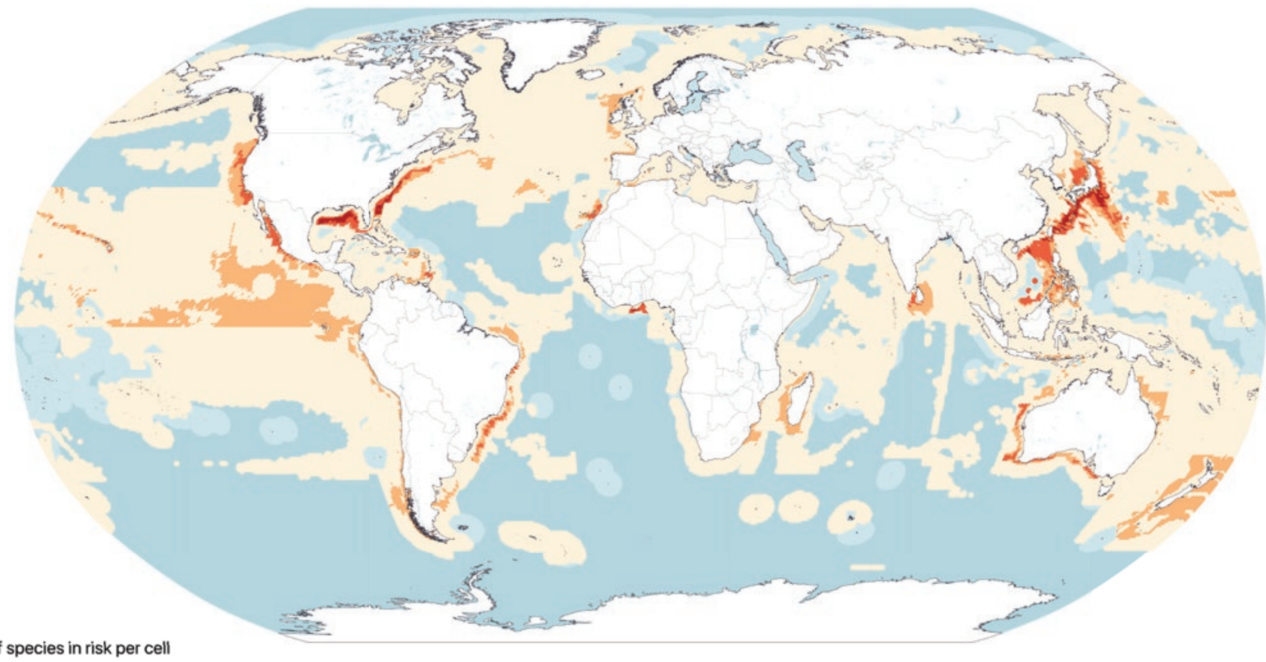
Humans have been hunting whales commercially for centuries, but technological advances in the late 19th and early 20th century meant that new regions and species were accessible to whalers.[81] During the period of "modern whaling" from 1900 to 1999, around 2.9 million large whales were caught globally.[15] The IWC, the organization that regulates whaling by its member nations under the International Convention for the Regulation of Whaling, set a zero-catch limit for commercial whaling on all whale species and populations from the 1985/1986 season onwards, referred to as the commercial whaling moratorium.[82] However, nations including Iceland, Norway and Japan have caught whales commercially since then, under formal objection or reservation to the moratorium.[82] These takes have been mostly minke whales (*Balaenoptera acutorostrata*) and Antarctic minke whales. Until 2019, Japan availed of an exemption for "scientific whaling" under Article VIII of the Convention[83] to conduct whaling outside its exclusive economic zone (EEZ). There was widespread scepticism that such whaling was scientific in any meaningful sense. When it was successfully challenged in the International Court of Justice and in the governing bodies of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Japan left the IWC in 2019 and began catching whales commercially in the same year, since it was not bound by the moratorium after leaving the IWC.[81,84] Iceland has not caught whales since 2018 when it reported 152 catches, mainly of fin whales (*Balaenoptera physalus*). In 2019, Japan took 256 whales, mainly Bryde's whales (*Balaenoptera edeni*), and Norway took 429 common minke whales.[85]

Hunting of small cetaceans for fisheries bait

Hunting of small cetaceans – for live capture, food, bait and other products – is ongoing in many parts of the world and some of it is unsustainable. Few countries regulate small cetacean hunts and globally the number of small cetaceans taken, deliberately or otherwise, is unknown.[17]

The use of marine mammals, including small cetaceans, as bait has affected many species and is a geographically widespread activity, is a geographically extensive activity, affecting at least 42 species in 33 countries, predominantly in Latin America, Asia and West Africa where socioeconomic factors motivate fishers to seek a bait that is effective, fresh and inexpensive or free. It is also a product of fisheries interactions and is illegal in most places. Shark fisheries that employ longlines appear to be the most widely engaged in the practice.

TOOTHED WHALES



BALEEN WHALES

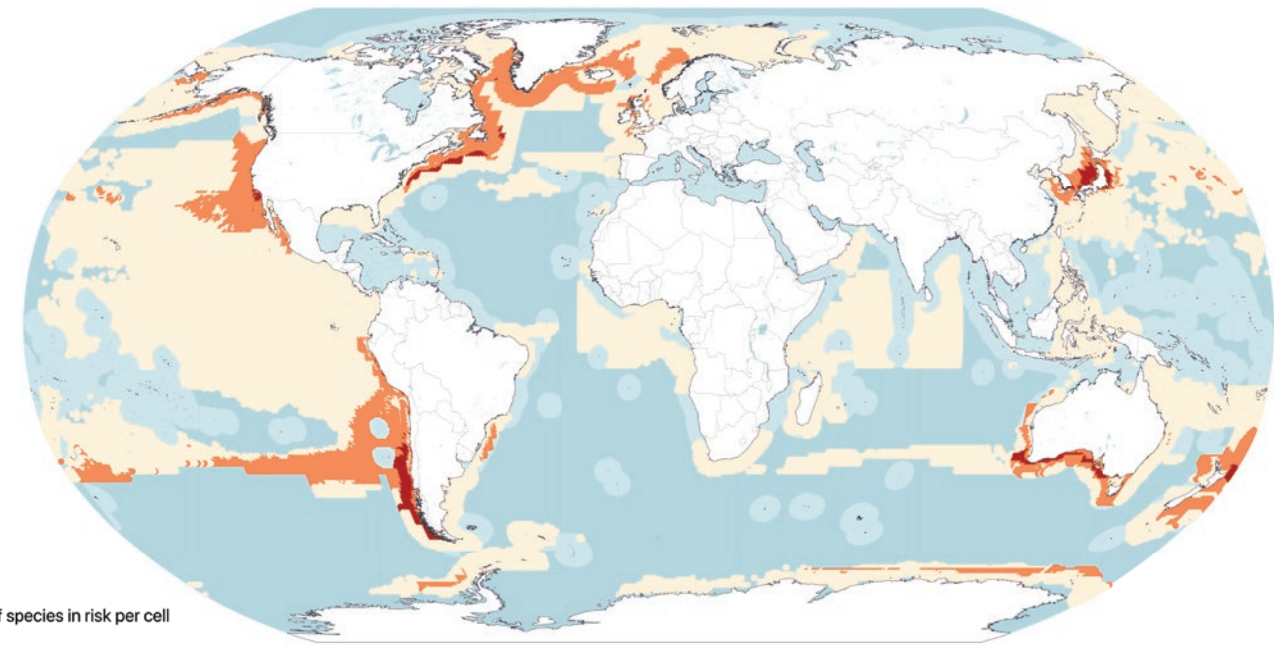
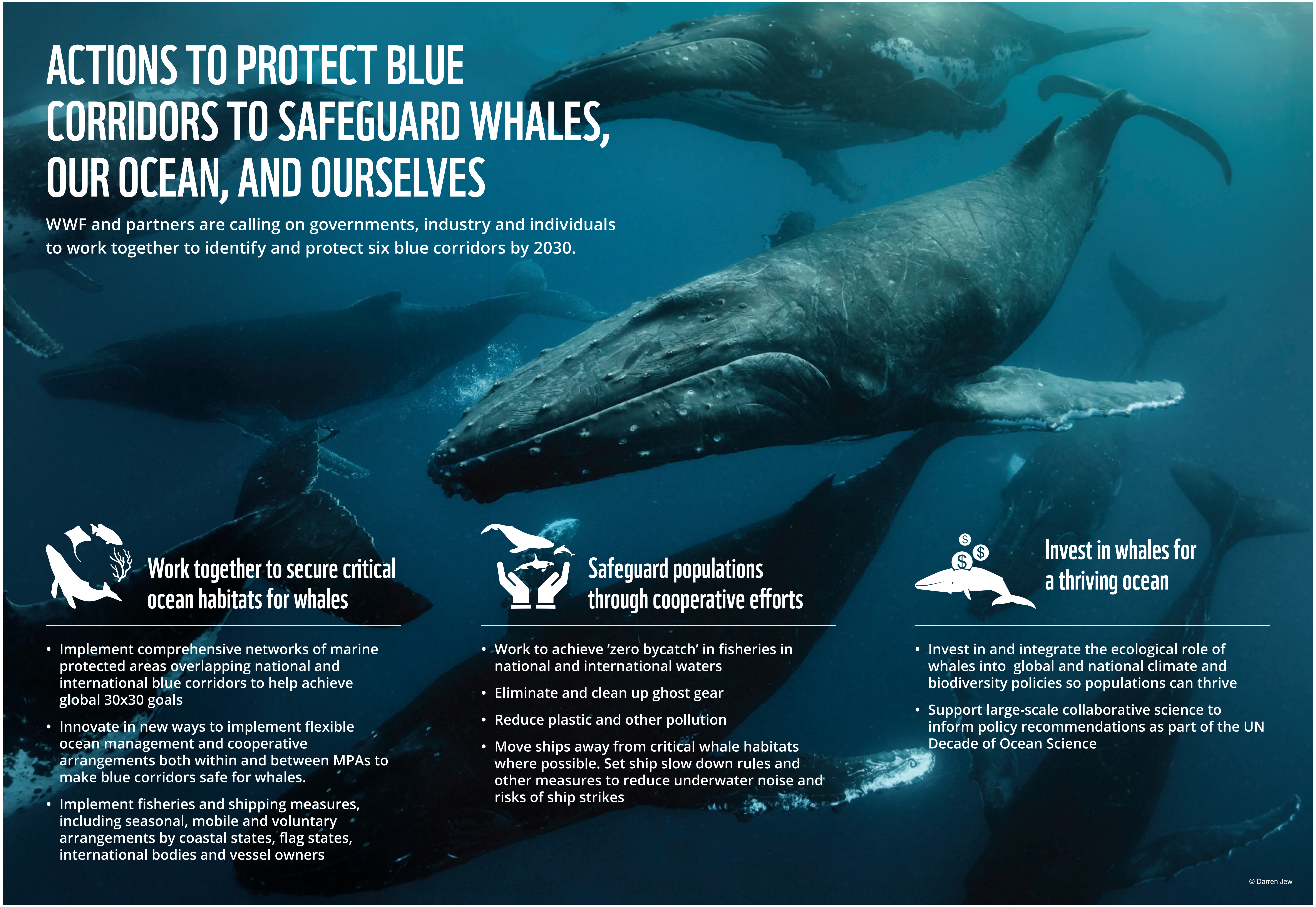


Figure 2: Cumulative risks maps from Avila et al (2018)[16] showing the number of species affected by any threat based on the intersection of published documented threat categories (all threat types) and predicted species core habitat (AquaMaps presence probability threshold ≥0.6). Blue areas represent the core habitats for each group without any documented threat. Red areas represent high-risk areas or hotspots. (A) Cumulative risk map for toothed whales (Odontocetes, N species = 65). (B) Cumulative risk map for baleen whales (Mysticetes, N species = 13).

Indigenous whaling

Subsistence hunting of whales by Indigenous peoples is a vital part of their cultures, nutrition and subsistence economies and is recognised by the International Whaling Commission as such. Hunting of some great whales, primarily bowhead whales, by Indigenous peoples in Greenland, Russia and the US is regulated by the IWC and comprehensively monitored to ensure whale populations remain at (or are brought back to) healthy levels.[425]

Narwhal and beluga whales are also subsistence hunted by many coastal Indigenous communities across the Arctic. Subsistence use is managed mostly at the national and sub-national level, according to legal frameworks and through management and co-management bodies. While climate change is the primary long-term threat to whales in the Arctic, many populations are being increasingly exposed to shipping, pollution and other industrial pressures.[86] Cook Inlet beluga whales experienced a decline in the 1990s thought to be due to subsistence hunting and now face additional threats to recovery, including shipping and oil and gas exploration.[426] In a population of narwhal in East Greenland, scientific advice from the North Atlantic Marine Mammal Commission (NAMMCO) – a regional body for management of cetaceans and other marine mammals – indicates that a combination of climate change, hunting and possible disturbance from shipping is putting the species at risk of local extirpations.[87,427]



ACTIONS TO PROTECT BLUE CORRIDORS TO SAFEGUARD WHALES, OUR OCEAN, AND OURSELVES

WWF and partners are calling on governments, industry and individuals to work together to identify and protect six blue corridors by 2030.

Work together to secure critical ocean habitats for whales

- Implement comprehensive networks of marine protected areas overlapping national and international blue corridors to help achieve global 30x30 goals
- Innovate in new ways to implement flexible ocean management and cooperative arrangements both within and between MPAs to make blue corridors safe for whales.
- Implement fisheries and shipping measures, including seasonal, mobile and voluntary arrangements by coastal states, flag states, international bodies and vessel owners

Safeguard populations through cooperative efforts

- Work to achieve 'zero bycatch' in fisheries in national and international waters
- Eliminate and clean up ghost gear
- Reduce plastic and other pollution
- Move ships away from critical whale habitats where possible. Set ship slow down rules and other measures to reduce underwater noise and risks of ship strikes

Invest in whales for a thriving ocean

- Invest in and integrate the ecological role of whales into global and national climate and biodiversity policies so populations can thrive
- Support large-scale collaborative science to inform policy recommendations as part of the UN Decade of Ocean Science

GREAT WHALE MIGRATIONS

We present a series of case studies that are based on satellite tracking, photo identification and other data sources to illustrate emerging blue corridors for whales, some of the hotspots where there is growing human interference, and ideas for regional conservation solutions.

EASTERN PACIFIC OCEAN

Climate change, ship traffic, underwater noise and fishing activity are impacting whales along multiple points on their important migration routes that are crucial for their survival.

BERING STRAIT

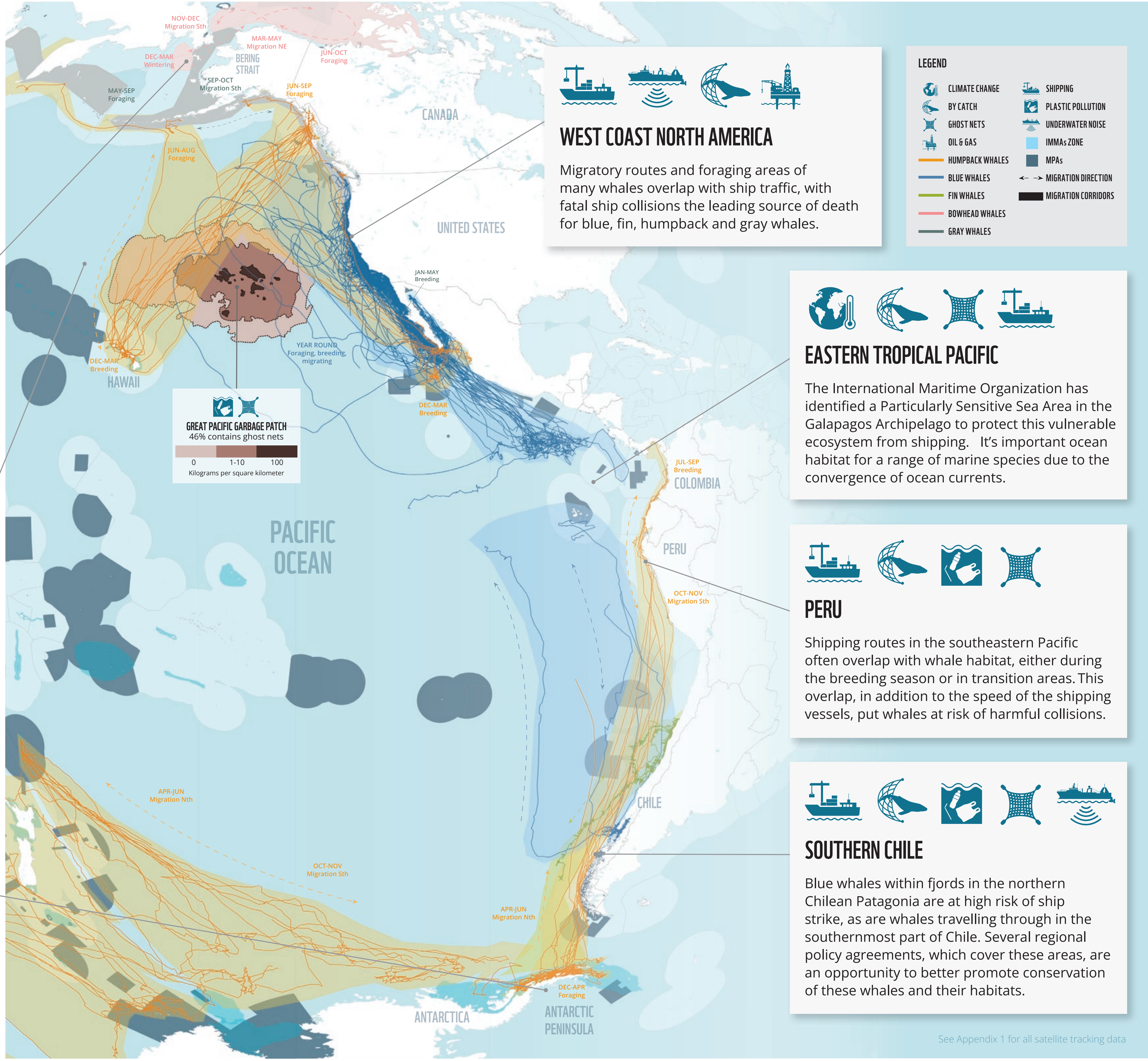
A key migratory corridor for millions of animals, including whales, which are contending with the risk of oil spills, ship strikes, underwater noise pollution and a marine ecosystem under pressure from a warming climate. National action and international cooperation are urgently needed to better manage fishing and shipping in the region.

HAWAII TO SOUTHEAST ALASKA

Patterns of ocean currents in this region lead to the formation of convergence zones, most famously the "Great Pacific Garbage Patch," where abandoned, lost and discarded fishing gear (ALDFG) tends to accumulate, increasing the risk of entanglement. While the Hawaiian humpback whales has been recovering strongly, recent climate-related "marine heatwaves" appear to have impacted birth rates.

ANTARCTIC PENINSULA

There is increasing overlap between industrial fishing for Antarctic krill and foraging of krill by whales, penguins, seals, seabirds and fish. A new marine protected area proposal will help to conserve important Antarctic biodiversity and reduce this overlap.



WEST COAST NORTH AMERICA

Migratory routes and foraging areas of many whales overlap with ship traffic, with fatal ship collisions the leading source of death for blue, fin, humpback and gray whales.

EASTERN TROPICAL PACIFIC

The International Maritime Organization has identified a Particularly Sensitive Sea Area in the Galapagos Archipelago to protect this vulnerable ecosystem from shipping. It's important ocean habitat for a range of marine species due to the convergence of ocean currents.

PERU

Shipping routes in the southeastern Pacific often overlap with whale habitat, either during the breeding season or in transition areas. This overlap, in addition to the speed of the shipping vessels, put whales at risk of harmful collisions.

SOUTHERN CHILE

Blue whales within fjords in the northern Chilean Patagonia are at high risk of ship strike, as are whales travelling through in the southernmost part of Chile. Several regional policy agreements, which cover these areas, are an opportunity to better promote conservation of these whales and their habitats.

EXPLAINER: HOW DO WE KNOW WHERE WHALES MIGRATE?

Satellite tracking

For several decades, scientists have used satellite tracking – also known as satellite telemetry – to better understand the movement patterns and large-scale behaviour of marine mammals. Satellite tags have been developed to track marine mammals for several months at a time, collecting spatial information using orbiting satellite networks. Similar to a GPS, satellite tags send and receive signals to and from satellites several times per day and these are used to calculate the position of the tagged animal. Data is sent via satellite and computer to users and offers a remote means for watching animals that otherwise would be nearly impossible to track. Over time, positions from satellite tags can be used to determine the behaviour of the tagged animal (for example, migrating or transiting versus foraging) by using mathematical animal movement models. Because satellite tags can collect data over long periods, they are a useful tool for understanding fundamental aspects of the life history of marine mammals, including when and where they migrate, how much time they spend in migratory corridors and where these corridors may overlap with human activities.

To study whale migration, satellite tags are generally deployed on animals on their breeding or feeding grounds while animals are close to shore and are remaining in more or less the same area. As animals transition to migratory behaviour, satellite tags provide critical information on when migration occurs, the routes that animals take during migration, and when they reach their destination. Continuously tracking migrating animals is nearly impossible to do from a logistical point of view without the aid of satellite transmitters. By using satellite tag technology, scientists can learn, for example, about the routes that marine mammals take, the speed at which they move and whether different portions of the population migrate at different times. Additionally, satellite tag data can be used to show when migrating marine mammals overlap in space and time with human activities such as fishing and shipping, and to determine the amount of time that animals spend in the territorial waters and EEZs of different countries.

Photo-identification

One of the most commonly used methods for tracking the movements of marine mammals is photo-identification. Most animals have markings that are unique to individuals and in the case of baleen whales, specifically humpback whales, the patterns of scarring and pigmentation on the underside of the tail flukes can be used to identify individuals with great precision. Photographing animals is a relatively simple and passive way to collect valuable information on the presence of an animal in a certain place at a certain time. By collecting fluke (or other body part) images regularly in the same place, researchers can learn about occurrence patterns of individuals over long periods

A humpback whale fluke

Southern right whales

of time or within a season. However, some of the most critical information on animal movements comes from when researchers compare photographic images across regions to make matches. In this case, many of the main migratory end points (feeding and breeding grounds) for marine mammal populations have been identified and fidelity to these has been established for many individuals.

Photo-identification is likely the most ubiquitous marine mammal data collected around the world and enables researchers to define migratory destinations for populations and the patterns of occurrence of individuals in these areas over time. As well, photo-identification can help determine the frequency of reproduction in individuals and can provide information on entanglements and other scars/injuries incurred from incidents with human activities.

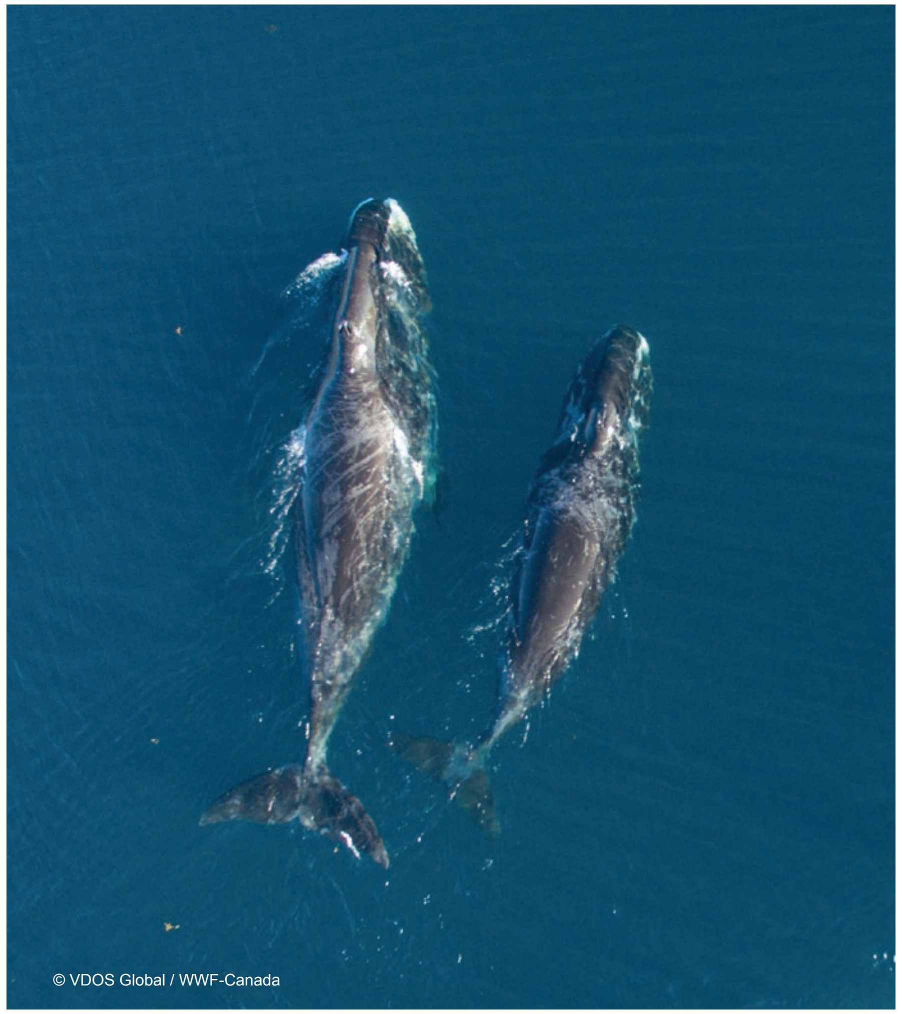
Indigenous Knowledge

Vast knowledge about whales, their movements, behaviour and ecology is held by coastal Indigenous peoples around the world, particularly those who have relied and still rely on whales for their culture, food and livelihoods. Indigenous Knowledge, or Traditional Ecological Knowledge, is accumulated by people who have successfully lived in close connection with nature for generations, often in remote places, and often as the only year-round residents, enabling deep, detailed and experiential observations and knowledge to be gained.

Indigenous Peoples' knowledge is increasingly recognized by scientists as unique and intrinsic to understanding the nature of biodiversity and ecosystems. Indigenous Knowledge has been used alone and alongside scientific research to understand whale migrations, including pathways, timing, changes and factors influencing its onset (e.g. for beluga and bowhead whales).[88,89]

BERING STRAIT

The Bering Strait connects the Arctic to the Pacific Ocean. Each year it hosts immense seasonal migrations of more than one million marine predators, including bowhead, beluga and gray whales (*Eschrichtius robustus*), seals and walrus. The Bering Strait is a key migratory corridor, a persistent hotspot for many marine species, and is one of the world's most productive marine ecosystems.[90,428]



Seasonal migrations of Arctic and subarctic marine mammals closely follow the timing of sea ice retreat north in spring and its advance south in autumn. The highly productive, plankton-filled cold Arctic waters north of the Bering Strait also attract temperate cetacean species from the Pacific Ocean up through the Strait and into the Arctic Ocean to exploit these rich feeding grounds in summer months. Gray whales travel more than 16,000km annually to and from Mexico.[91,92,93] Humpback whales frequent the Bering Sea in summer and can be found as far north as the Chukchi and Beaufort Seas.[93] As well as their importance to the marine ecosystem, populations of whales that migrate through the Bering Strait are of immeasurable importance to coastal Indigenous Peoples in Alaska and Russia, who have relied on them for millennia for their culture, nutrition and livelihoods.[91,94]

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CONSERVATION CHALLENGES

A changing Arctic

The Arctic is warming more than twice as fast as the rest of the planet due to anthropogenic climate change and is now warmer than it has been at any time during the last 2,000 years.[40,95] A major consequence of this is loss of sea ice. Summer ice extent has declined by 40 per cent since satellite observation began in 1979 and what remains is younger and thinner, melts earlier in spring and re-freezes later in autumn.[40]

Sea ice is an important habitat for Arctic marine mammals and, until recently, it has been a physical barrier to heavy industrialization of the Arctic Ocean and associated impacts. However, as the ice-free season lengthens, this is rapidly changing. Financial experts estimate that future development in the Arctic will attract approximately a trillion dollars of new spending in the next 20 years.[96] Realisation of new development and infrastructure plans, stimulated by global demand for resources, is now possible due to the climate crisis.

Extremely warm conditions in recent years have put the Pacific Arctic marine ecosystem under high pressure.[91] Whales in the Bering Strait region are contending with changes in prey availability, a higher risk of predation by killer whales and changes in sea ice and other climate drivers that cue migration and other life events.[91,97,98] Early signs of transformative change in the region include shifts in the productivity and distribution of fish species, changes in migrations of bowhead and beluga whales, and unusual mortality events for ringed, spotted and bearded seals and gray whales.[51,91,98–100]

Growing risks for cetaceans

On top of these dramatic ecosystem changes, multiple anthropogenic stressors are growing in the Bering Strait region. Projected increases in ship traffic and expanding commercial fisheries carry direct risks for cetaceans.

Known as the "fish basket" of the United States, the southeastern Bering Sea contains major fish stocks that make up a US$2 billion fishery[101] and account for about half the seafood landings in the country. As these fish stocks move northwards due to climate change, so too will commercial fishing pressure. In 2020, the Russian Federation announced plans to open the first commercial pollock fishery in the Chukchi Sea to take advantage of this species' apparent range expansion.[102]

Shipping activity in the Bering Strait overlaps in space and time with whale migrations and brings several risks, including oil spills, ship strikes and underwater noise pollution. The number of ships transiting the Bering Strait has almost doubled in the last decade. Where only 262 transits were recorded in 2009, in 2019 approximately 494 ship transits were observed through the Strait, with large increases projected in the future.[103,104] Excess underwater noise pollution from current shipping – the amount of additional noise on top of the ambient underwater soundscape – is well above levels known to have a negative impact on whale communication.[105]

In addition to increases in shipping through the Bering Strait for local or national commerce, with the loss of sea ice, new global shipping routes through the Arctic are materializing to connect the world's oceans. Of four such routes, three would pass through the Bering Strait: the Northwest Passage, the Northeast Passage (which includes the Northern Sea Route) and the Transpolar Sea Route. All offer significant benefits of shorter distances compared to those through the Suez and Panama Canals.[40]

CONSERVATION OPPORTUNITIES AND SOLUTIONS

International action to regulate shipping needed now

The Bering Strait is clearly an important migratory corridor for marine wildlife and is vital for the many coastal Indigenous Peoples who use marine resources as an integral way of life. Climate change is also creating opportunities for commercial and industrial growth that will result in new and elevated risks for the Bering Strait marine ecosystem and its components, including endemic species like bowhead and beluga whales and seasonal visitors such as gray and humpback whales.

Commercial activities including fishing and shipping must be managed through national action and international cooperation, especially between the Russian Federation and the United States, whose national waters abut in the Bering Strait. Development of a holistic system to manage shipping, thereby improving maritime safety and environmental protection, could include the use of emerging e-navigation technologies to enable real-time monitoring and information exchange; development of seasonal or dynamic MPAs; adoption of voluntary or mandatory speed restrictions and standards of care and operation led and implemented by the maritime industry.[36,104]

WWF is working with governments, local communities, and other conservation organizations in Russia and the United States to identify area-based protections in Bering Strait to protect whales and other marine mammals, and the communities that rely on these areas. Areas to Be Avoided (ATBAs) are special areas identified by the International Maritime Organization (IMO) to keep large vessels away from sensitive habitats. WWF has identified the Diomede Islands as important areas that require further protection and recommend implementing ATBAs around both islands.

With transformation of this marine ecosystem underway, protection of these migratory corridors to maintain ecological connectivity and the immense natural values of the region is a matter of urgency.[104]

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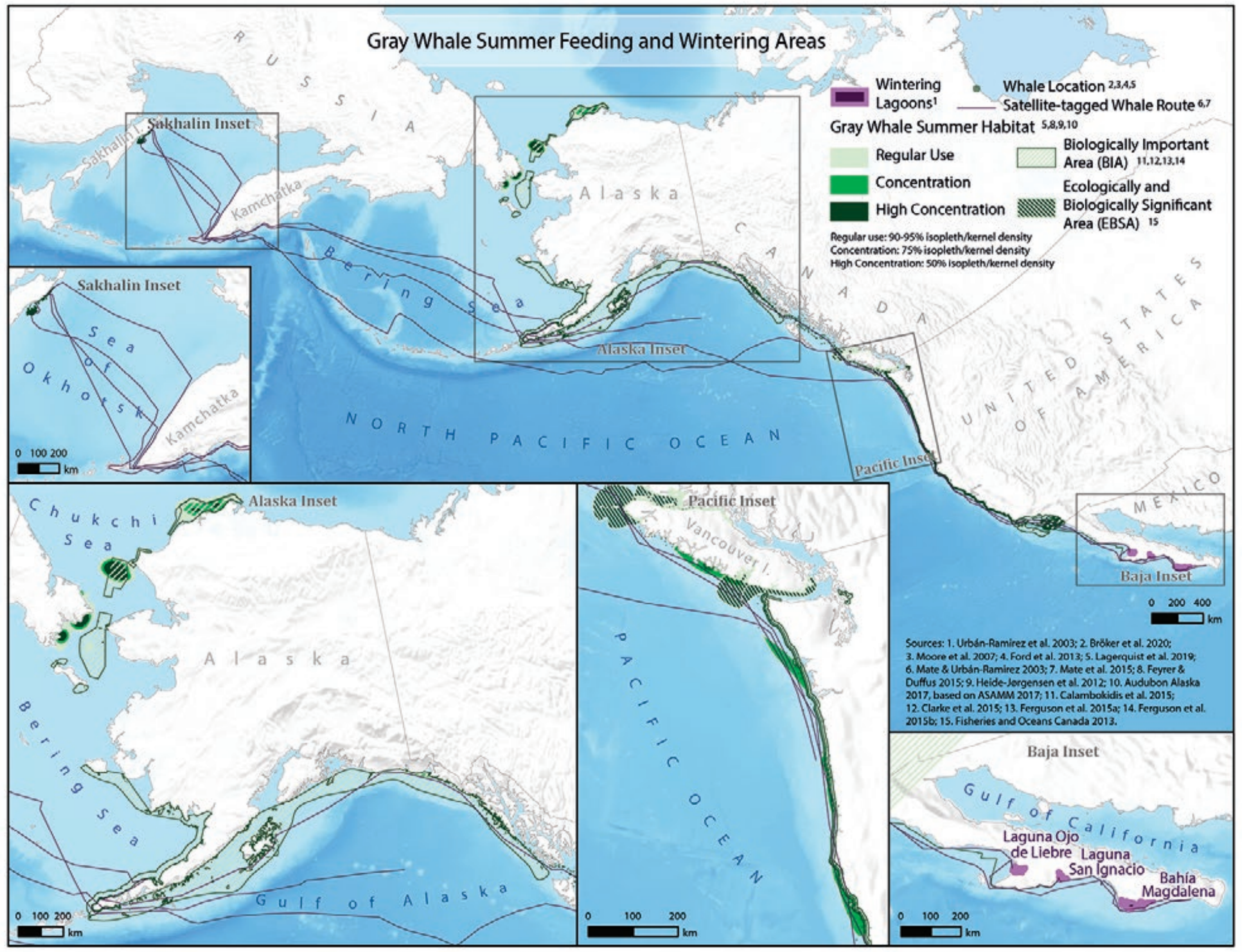


Figure 3: Satellite tagging shows the yearly round-trip migration between the Arctic and Mexico along the west coasts of Canada and the United States.

CETACEAN FALL DISTRIBUTION AND VESSEL TRAFFIC

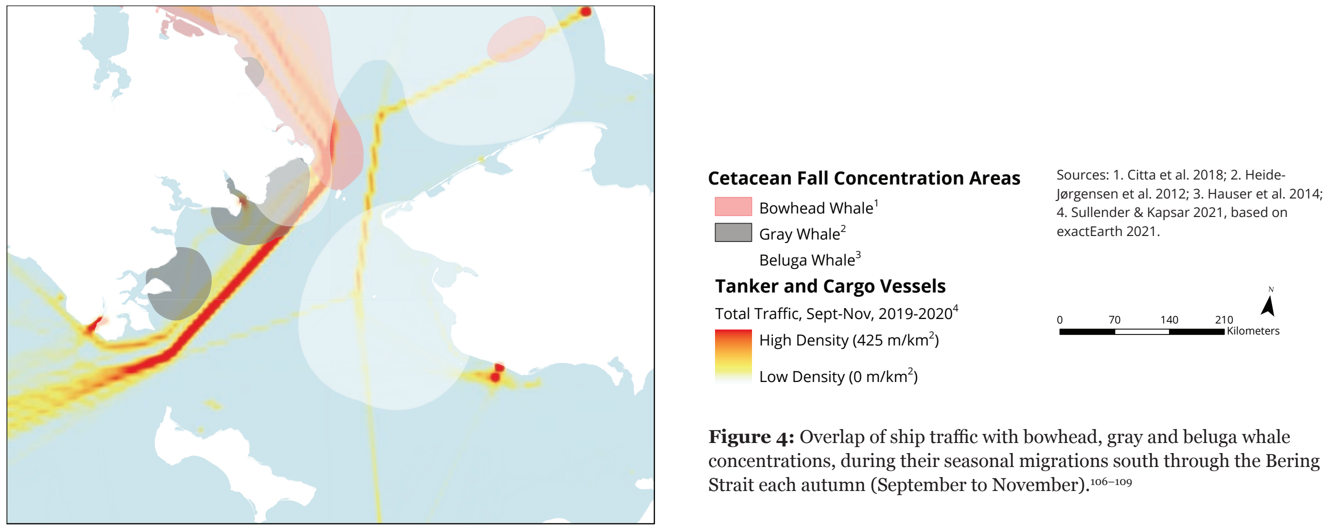


Figure 4: Overlap of ship traffic with bowhead, gray and beluga whale concentrations, during their seasonal migrations south through the Bering Strait each autumn (September to November).[106–109]

HAWAII TO SOUTHEAST ALASKA

The importance of the Hawaiian Islands as a breeding area for North Pacific humpback whales is underscored by the fact that it is used during winter months by almost half (about 10,000 animals) of the population inhabiting the North Pacific.[110] These whales come from various high-latitude feeding areas across the North Pacific, but the vast majority originate in southeast Alaska and adjacent feeding areas in northern British Columbia and the northern Gulf of Alaska.[110]

The migration to and from the feeding areas takes the whales across a vast expanse of the open ocean that is regularly crossed by major shipping "highways" where the risk of ship strike is elevated.

Humpbacks are abundant in Hawaii from mid-December through early April, reaching peak numbers in February and March, when most females are believed to go into estrus.[111] The pattern of male activity around females suggests that the peak in ovulation for non-pregnant females is from December to early February, while a secondary peak from mid-February to March appears to be the result of pregnant females from the previous winter going into estrus after giving birth. Mating occurs during the brief period (a few days) when females are receptive, so most individuals (certainly most females) may be present in Hawaii for only a few weeks.[111]

Thus, we might expect that a typical adult female that has spent spring, summer and part of the autumn in the feeding areas may migrate to Hawaii (a distance of ~4,000–5,000km) in late autumn (say, late November), arrive there 30 to 40 days later (late December), remain in Hawaii for 20 to 30 days (40 days if rearing a calf) while looking for a mate, and then undertake the return migration to finally arrive in the feeding area at the beginning of spring (mid-March) of the following year. The pattern of male residence in Hawaii is possibly similar, although the most dominant ones may spend significantly longer (up to 91 days).[111]

A recent comprehensive analysis of the movements of 86 satellite tagged animals in Hawaii from 1995 to 2019 showed that while in the Hawaii breeding area, whales moved at a mean speed of 1.62km/h and that their residency ranged from 1.1 to 42.8 days, with a mean of 13.1 days.[112] Once they started their migration to the feeding areas, tagged whales moved at a mean speed of 4.65km/h and their migration lasted between 28 and 44.8 days, with a mean of 34.2 days.[112] However, migration speed was not sustained but showed variation over time, with periods of increased and decreased speed lasting several days.[112]


© naturepl.com / Tony Wu / WWF

CONSERVATION CHALLENGES

By virtue of Hawaii's location in the middle of the North Pacific, the migration to and from the feeding areas takes the whales across a vast expanse of the open ocean that is regularly crossed by major shipping "highways" where the risk of ship strike is elevated.[113] Patterns of ocean currents in this region lead to the formation of convergence zones, most famously the Great Pacific Garbage Patch, where abandoned, lost or discarded fishing gear tends to accumulate,[30,32,114,115] increasing the risk of entanglement. At least 46 per cent of the Great Pacific Garbage Patch is made of discarded fishing gear.[32]

While the Hawaiian humpback whale population has been recovering strongly,[116] recent climate-related perturbations to the North Pacific ecosystem known as "marine heatwaves" appear to have affected survival and recruitment in this population.[117–120]

CONSERVATION OPPORTUNITIES AND SOLUTIONS

Preventing fishing gear loss is the top priority, with education, voluntary measures and regulations all having a role to play. Prevention measures include restricting the use of high-risk gear in certain areas or times of year, marking fishing gear so it's clearly visible and the owner can be identified, and improving end-of-life disposal and recycling.

Even so, some fishing gear will inevitably get lost, so it's important to adopt mitigation measures. Including biodegradable components so the gear breaks down quickly is one effective way to prevent ghost fishing. Finally, since plastic gear can have long-lasting impacts, it's important to remove and retrieve as much lost and abandoned gear as possible, though this can be expensive, particularly in deep-sea habitats. Programmes for reporting and retrieving lost gear already operate in some places, and "fish for litter" schemes – which reward fishers for bringing back marine debris, including ghost gear – are growing in popularity.[29]

WWF is urging governments to sign on to the Global Ghost Gear Initiative (GGGI) and implement its fishing gear best management practices to prevent gear loss. The GGGI is the world's only global cross-sectoral alliance of 100 organizations, including WWF. By joining the GGGI, countries will access critical technical support to address ghost gear in their national fisheries, contribute to the collective impact of GGGI and its members, and help to develop the global capacity to solve this problem throughout our ocean.[29]

Globally, a legally binding UN agreement is needed as a priority to stop the leakage of plastics into our oceans by 2030 and accelerate the transition to a circular economy for plastic so it never becomes waste or pollution.[121]

WESTERN COAST OF NORTH AMERICA

The coastal waters of North America are important migratory routes and foraging areas for species including gray, blue, humpback and fin whales. Blue whales move between the eastern tropical Pacific and the California Current System or Gulf of Alaska, but probably feed year-round, targeting ephemeral, dynamic concentrations of krill.

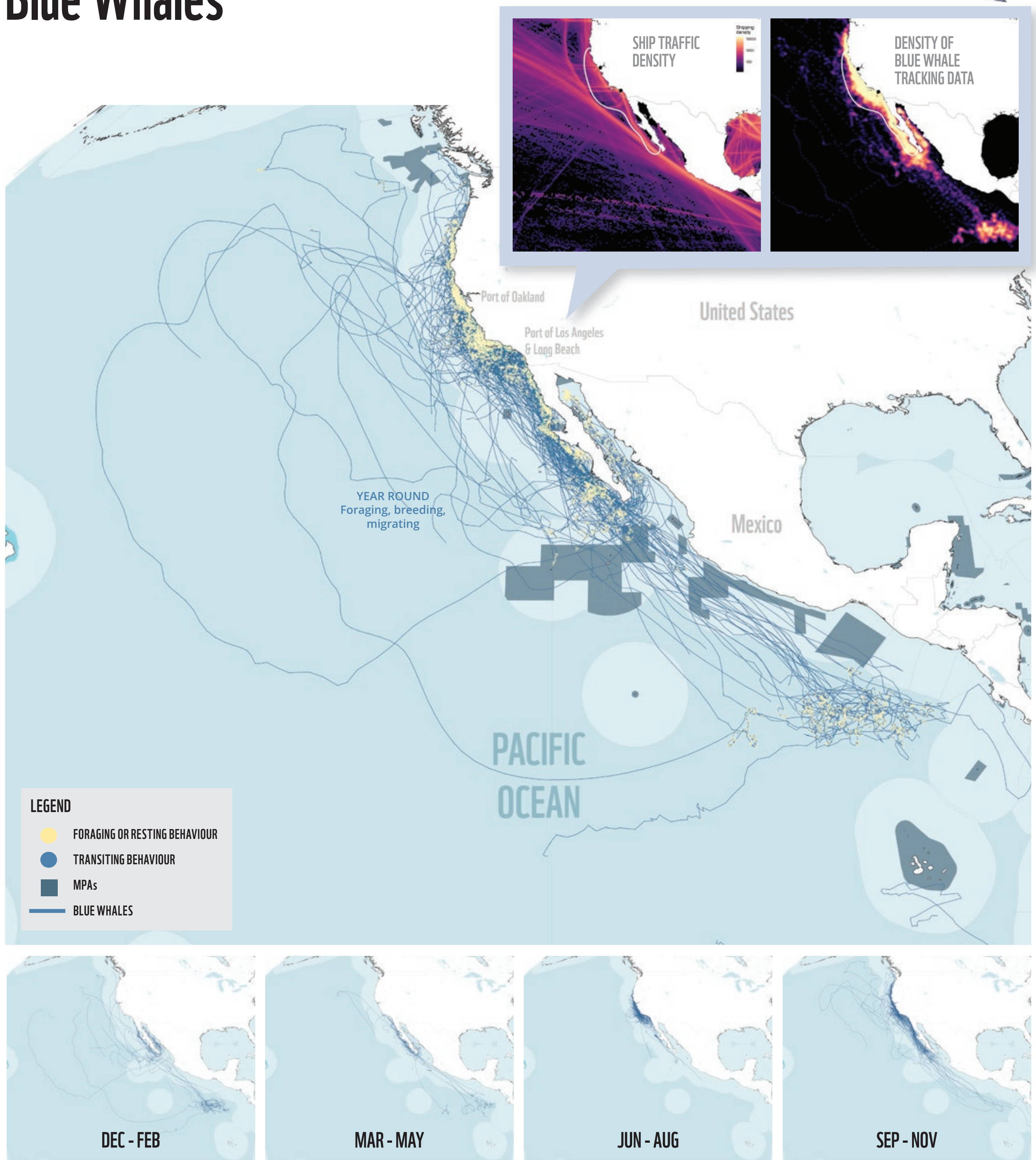
Fatal collisions with ships are a leading source of mortality for blue, fin, humpback and gray whales,[129] and may be one of the factors inhibiting recovery of blue whale populations post-whaling.

Blue whales in the eastern North Pacific are listed as Endangered under the United States Endangered Species Act and Protected under the United States Marine Mammal Protection Act. Their population size in this region is about 1,500 animals.[122] They migrate between the California Current region or the Gulf of Alaska and the eastern tropical Pacific, tracking abundant krill that they feed on year-round.

CONSERVATION CHALLENGES

Off the United States West Coast, migratory routes and foraging areas of many species overlap with various kinds of ship traffic,[123–128] including commercial traffic to and from the ports of Los Angeles and Long Beach, two of the world's 50 busiest container ports. The risk of collisions between ships and whales is thus high in this area: it is estimated that most mortality risk for blue, humpback and fin whales is concentrated in about 10 per cent of the United States West Coast EEZ.[128] Fatal collisions with ships are a leading source of mortality for blue, fin, humpback and gray whales,[129] and may be one of the factors inhibiting recovery of blue whale populations post-whaling.[128,130,131] Studies of the impacts of acoustic disturbance on blue whales has shown that these whales generally are affected disproportionately when feeding and as a result of disturbance, stop feeding.[132] Animals that are chronically exposed to disturbances, therefore, are at risk of losing critical foraging opportunities that can lead to changes in body condition that ultimately may lead to changes in reproductive rates and decreased population growth.[133]

Eastern North Pacific Blue Whales



Whale illustration © Uko Gorter

Figure 5: Over 17 years between 1994 and 2017, 189 whales were tracked for 2-504 days. Locations were recorded in the EEZs of nine countries with 15 per cent of locations recorded in the high seas. Most locations were in United States (52 per cent) and Mexican (32 per cent) waters. The satellite tracks cover an area of 23 million km². In this area, the mean shipping density (number of vessels counted in 2015) is 0.36 vessels/km², but in the whales' core-use area, it is 0.99 vessels/km².

A gray whale found dead off Point Reyes National Seashore in northern California. Photo by Barbie Halaska, The Marine Mammal Center.

CONSERVATION CONCERN: INCREASED GRAY WHALE STRANDINGS ALONG THE WEST COAST OF NORTH AMERICA

Since 1 January 2019, elevated gray whale strandings have occurred along the West Coast of North America from Mexico through Alaska. An unusual mortality event was declared by the National Oceanic and Atmospheric Administration (NOAA) in May 2019, and through May 2021 at least 454 strandings were reported, including 218 in Mexico, 218 in the United States and 18 in Canada.[134] The peak of the unusual mortality event was in 2019, and the number of strandings has been decreasing in 2020 and 2021. Most of these strandings have occurred from April through June, coinciding with the northbound migration from the breeding to the feeding areas, when the nutritional status of the whales is normally at its lowest. However, as the primary source of mortality appears to be severe malnutrition, it is likely that the deaths are related to a lack of food during the feeding season in the Arctic, primarily due to climate change.[135] Dramatic environmental changes took place in the North Pacific and the Arctic through the 2010s that likely affected the annual primary production cycles and the marine food chain, leading to the whales not finding sufficient food.[91]

The net result has been a loss of about 24 per cent of the eastern gray whale population from the 2016 estimate of around 27,000 whales.[134,136] During this time, the whales also appear to be arriving later by about a month to the breeding lagoons of Mexico in winter, although the departure dates have remained constant, suggesting that they are spending less time in the lagoons.[137] Health assessments have indicated an increasing number of whales in poor body condition, to more than 30 per cent of the animals in the breeding lagoons in recent years.[137] Gray whales feed on a diet of invertebrates but are otherwise opportunistic feeders and can use multiple strategies, including suction feeding, lunge feeding and skim feeding that allows them to exploit alternate prey. This flexible foraging strategy confers the species resilience against these short-term environmental fluctuations, which likely allowed the gray whale population to rebound to greater numbers than before after a similar unusual mortality event in 1999–2000, during which the population was reduced by 23 per cent.[136]

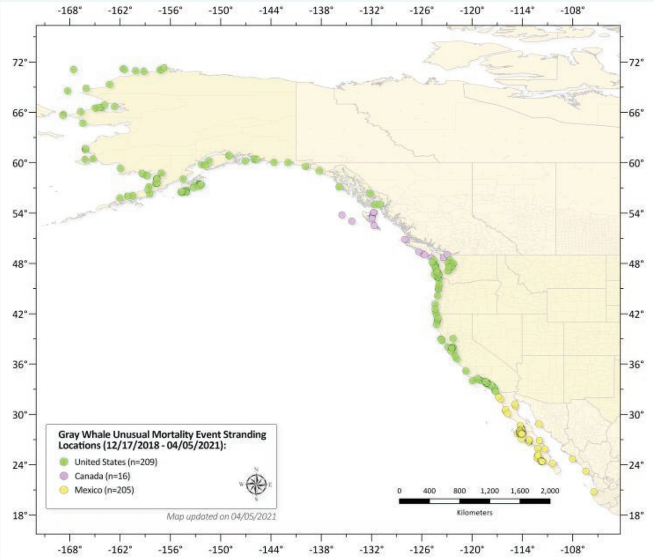
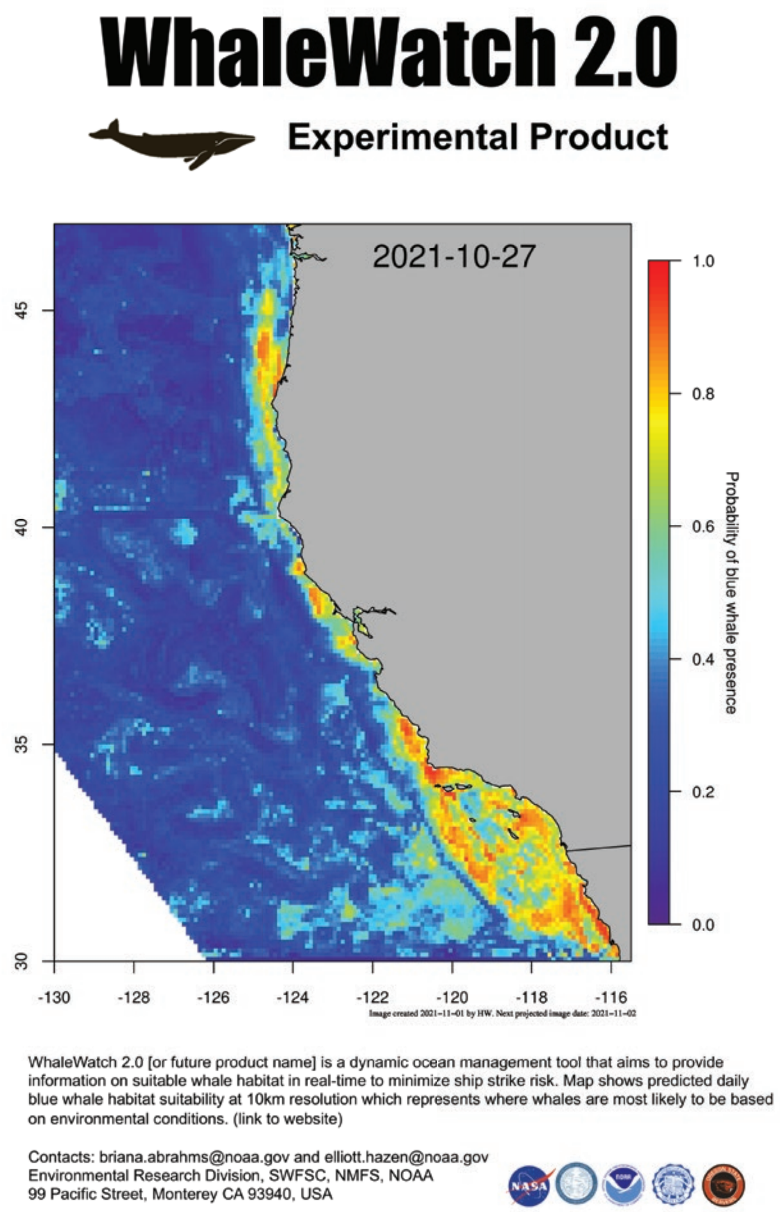


Figure 6: Map of gray whale strandings along the West Coast of North America through 5 April 2021.[134]



CONSERVATION OPPORTUNITIES AND SOLUTIONS

New technology to protect whales from shipping and fishing impacts

To help reduce human impacts on whales, a collaborative initiative between NOAA Fisheries, scientists and shipping companies developed WhaleWatch, a tool that provides predictions of where blue whales are likely to be off the United States West Coast.

The tool uses models that link whale tracking data to environmental conditions to predict whale presence.[125] This near real-time information helps reduce human effects on whales by providing information on where the whales occur and hence where whales may be most at risk from threats such as vessel strikes, entanglements and underwater noise.

For more information, visit https://coastwatch.pfeg.noaa.gov/projects/whalewatch2/

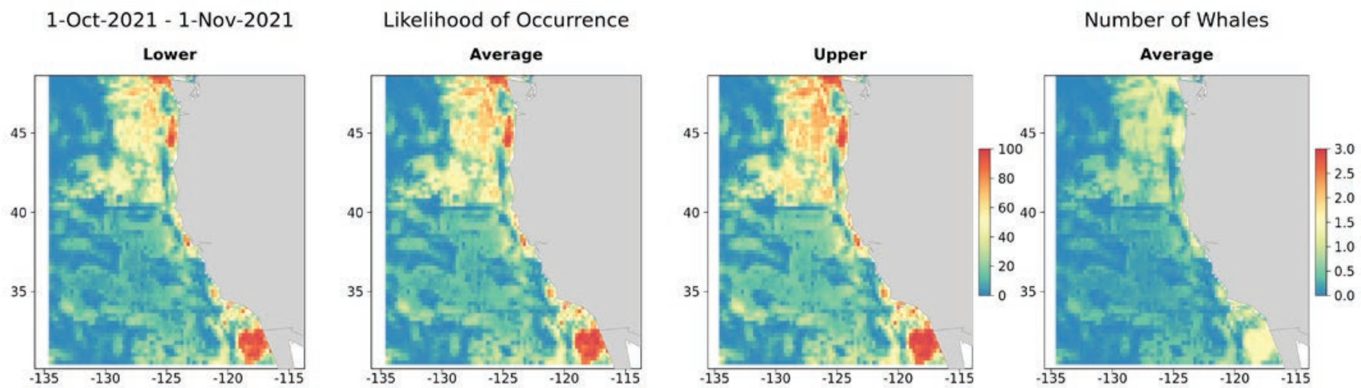


Figure 7: Model estimates for blue whales (*Balaenoptera musculus*) off the US West Coast for July 2021.
For more information about WhaleWatch visit https://fisheries.noaa.gov/west-coast/marine-mammal-protection/whalewatch

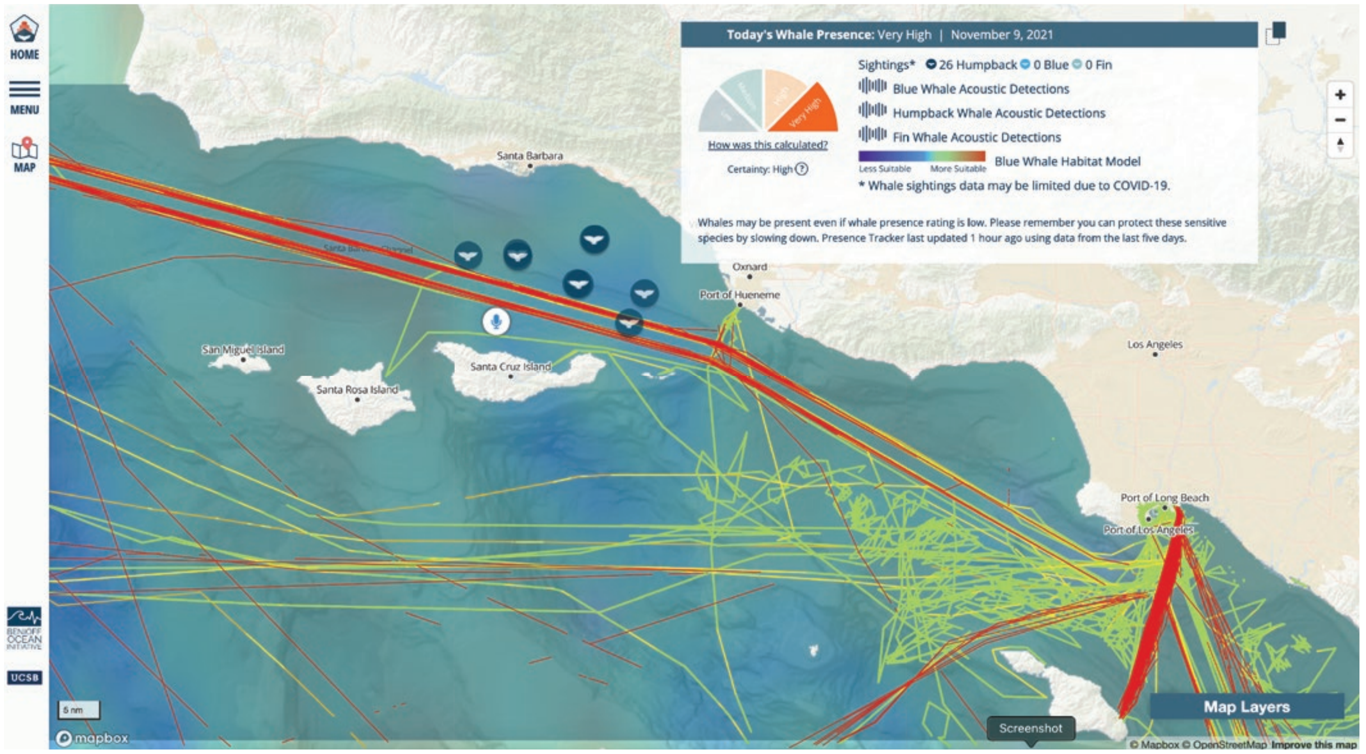


Figure 8: Whale Safe

Another recent, related effort is Whale Safe, a technology-based mapping and analysis tool developed by the Benioff Ocean Initiative and partners. The tool collects and displays near real-time whale and ship data for the Santa Barbara Channel, with the goal of helping to prevent fatal ship collisions with whales.[123,124,138] 2018 and 2019 were the worst years on record for whale-ship collisions off the West Coast of the United States. Despite this trend, there are solutions to combat the problem. Research demonstrates ships that slow to 10 knots in areas with high whale presence significantly reduce the danger to whales in the area.

For more information, see whalesafe.com

Network of MPAs and connectivity

In 1972, Mexico was the first country in the world to create a whale sanctuary in the Laguna Ojo de Liebre, a coastal lagoon in the Pacific coast of the Baja California Peninsula. This area is home of the most important gray whale breeding grounds.[1] Since then, a network of MPAs has been established, which now covers 22.05% of Mexico's marine territory.

In particular, the protected areas in the Mexican Pacific hold globally significant reproduction areas for migratory gray whales (the El Vizcaino Biosphere Reserve),[139] humpback whales (National Parks of Revillagigedo, Cabo Pulmo, Islas Marietas and Huatulco)[140,141] and blue whales (Loreto National Park)[142] as well as other key habitats along their migratory routes (the Islas del Pacifico de la Peninsula de Baja California, Islas Marias Biosphere Reserves and the Islas del Golfo de California Protection Area for Flora and Fauna).[143–145]

All cetaceans that occur in Mexico are protected by national legislation. Mexico's protected areas play a significant role managing critical habitats of migratory whales in North America, but need to be strengthened.[146] The development of environmental policies specifically designed to strengthen the conservation of whales, have contributed to strengthen the protection of migratory whales outside protected areas, increasing connectivity and community participation.[147] An official standard has been put in place to regulate all whale-watching activities, and response protocols for whale strandings and entanglements have been developed.[148–150]

At least 10 stranding networks work under the auspices of the Federal Attorney for Environmental Protection along the Mexican coasts. Such networks integrate staff from government agencies, research facilities and non-government organizations, and have assisted hundreds of strandings since 2014, but heavily rely on volunteers and lack government funding.[151] The National Whale Disentanglement Network integrates 15 trained teams of disentanglement experts with 180 volunteers along the Mexican Pacific Coast, all equipped with specialized gear to assist in the rescue of entangled whales. The network has been able to register 245 entanglements of six whale species, with humpbacks being the most affected (88 per cent). Just during the 2020–2021 season, the network received 37 entanglement reports and was able to successfully rescue 12 humpback whales. This network relies on philanthropic funding.

EASTERN TROPICAL PACIFIC (CENTRAL AMERICA TO CHILE)

The eastern Pacific encompasses some 20 million km^2 of territorial waters, EEZs and island territories of 11 countries, as well as an extensive marine area beyond national jurisdictions between Mexico and Chile (32 °N – 55 °S). The combination of ecosystem diversity and high productivity has fostered a high diversity of cetacean species in this vast region. More than 40 species of cetaceans inhabit the eastern Pacific, including nine baleen whales (*Mysticeti*) and more than 30 species of toothed cetaceans (*Odontoceti*).[152]

Understanding the large-scale distribution patterns of these species is critical to promoting their conservation. Because the breeding grounds of most migratory whales are in the tropics and subtropics, populations of the same species in both hemispheres may share the same breeding grounds in the tropics, but at different times of the year. This is the case of the humpback whale on the coasts of Central and South America and probably also with blue whales in the Galápagos Islands and the Costa Rica Dome.[153–156] The Costa Rica Dome is a regional centre of high productivity and likely supports high prey availability for cetaceans within the Dome and in surrounding waters. The productive equatorial waters of the Galápagos Islands also contains important regional habitats[157] and has been subject to recent high intensity industrial fishing along its EEZ.[158]

Sperm whales (*Physeter macrocephalus*) are another cosmopolitan species. Females and young males are found in tropical and subtropical waters. They are deep-diving predators with a broad diet of squid.[159] Other large whale species

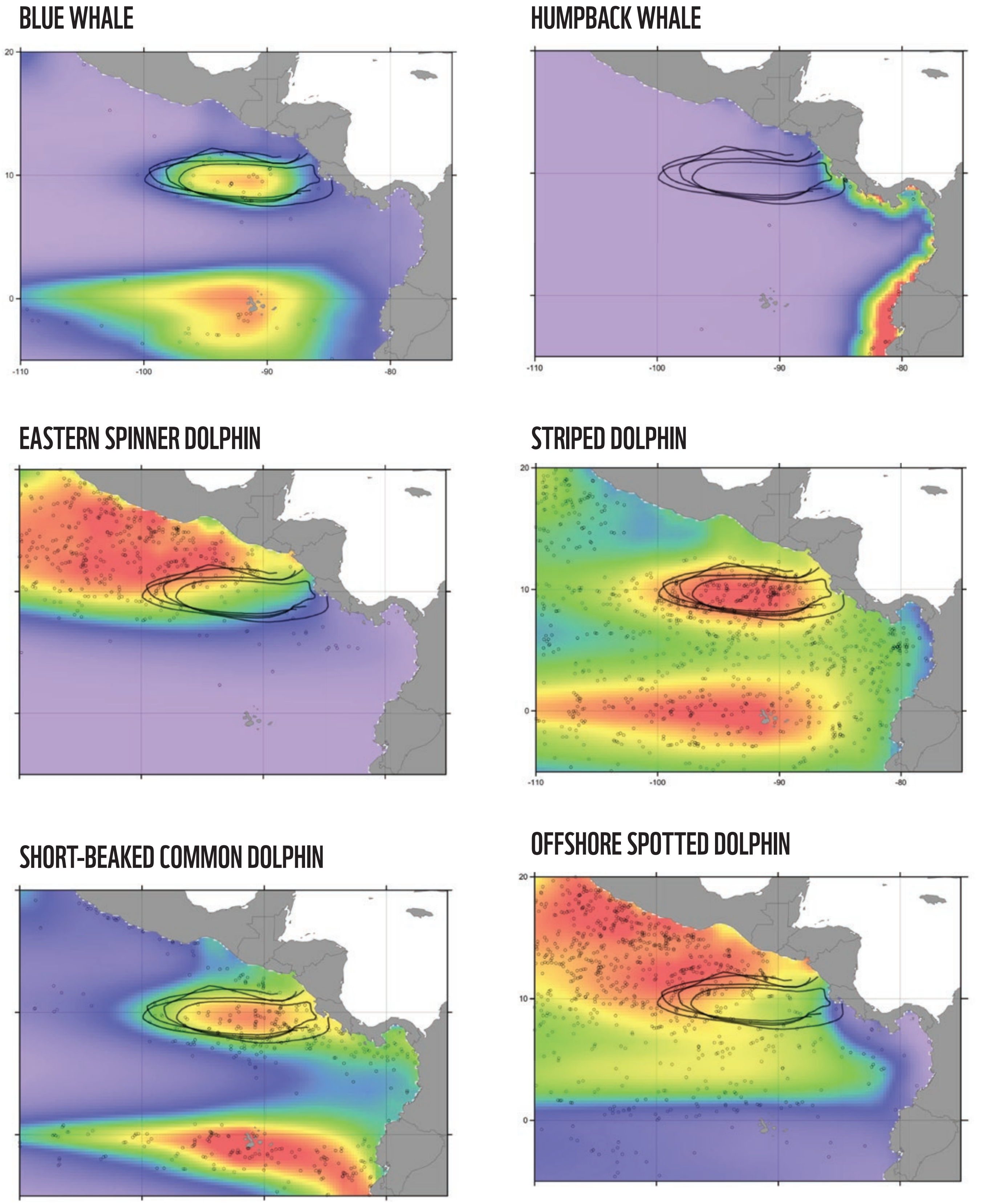


Figure 9: Maps of observed sightings and predicted number of sightings (increasing from light purple to red) for of blue whales and abundant toothed whales in the eastern tropical Pacific. The outlines are the August to November monthly climatological (1980–2015) locations of the Costa Rica Dome.[157] Spotted and spinner dolphins are often found in mixed schools, associated with tunas and seabirds.[167]

such as Bryde's whales also have wide ranges of distribution in the region, without an evident periodic migration.[160] Even so, both can show large-scale movements depending on the availability of food or specific oceanographic conditions.[161–163]

In this region, humpback whales breed in warm coastal waters from northern Peru north to central Costa Rica mainly from August to October. Satellite tracking studies of these whales have followed their long migrations along the Central and South America coast to the Antarctic Peninsula,[162–164] where they feed on krill in the Antarctic summer. Among whales tagged off Ecuador, mothers and their calves seemed to prefer the longer, coastal route to Antarctica, while lone adults seemed to prefer a more direct offshore route, sometimes hundreds of kilometres from the coast.[162] More recent tracking has revealed two bottleneck regions near the southern-most point of Chile as well as Peru's Illescas Peninsula.[164] The latter whales spent 64 to 79 per cent of their migration time in national waters and 21 to 36 per cent of their migration time in international waters.[164]

The coastal marine ecosystems of Chile are among the most productive in the world. This is particularly the case for the Chiloense Marine Ecoregion, a well-known coastal region of northern Patagonia with high biological productivity, great ecological value and the presence of emblematic species in serious states of conservation. Hundreds of blue whales and humpback whales migrate to the Chiloense Marine Ecoregion to feed and nurse their young every year, where the Corcovado Gulf, the Chiloé Archipelago's inner sea and Moraleda Channel are some of the most important feeding grounds in all of Patagonia.[165,166]

The Gulf of Corcovado is currently considered the largest feeding ground for blue whales in the southern hemisphere, where other baleen whales such as the humpback whale, sei whale and fin whale are frequently observed feeding or migrating. It is also possible to observe different species of toothed whales such as sperm whales, Peale's dolphins (*Lagenorhynchus australis*) and killer whales (*Orcinus orca*), among others.

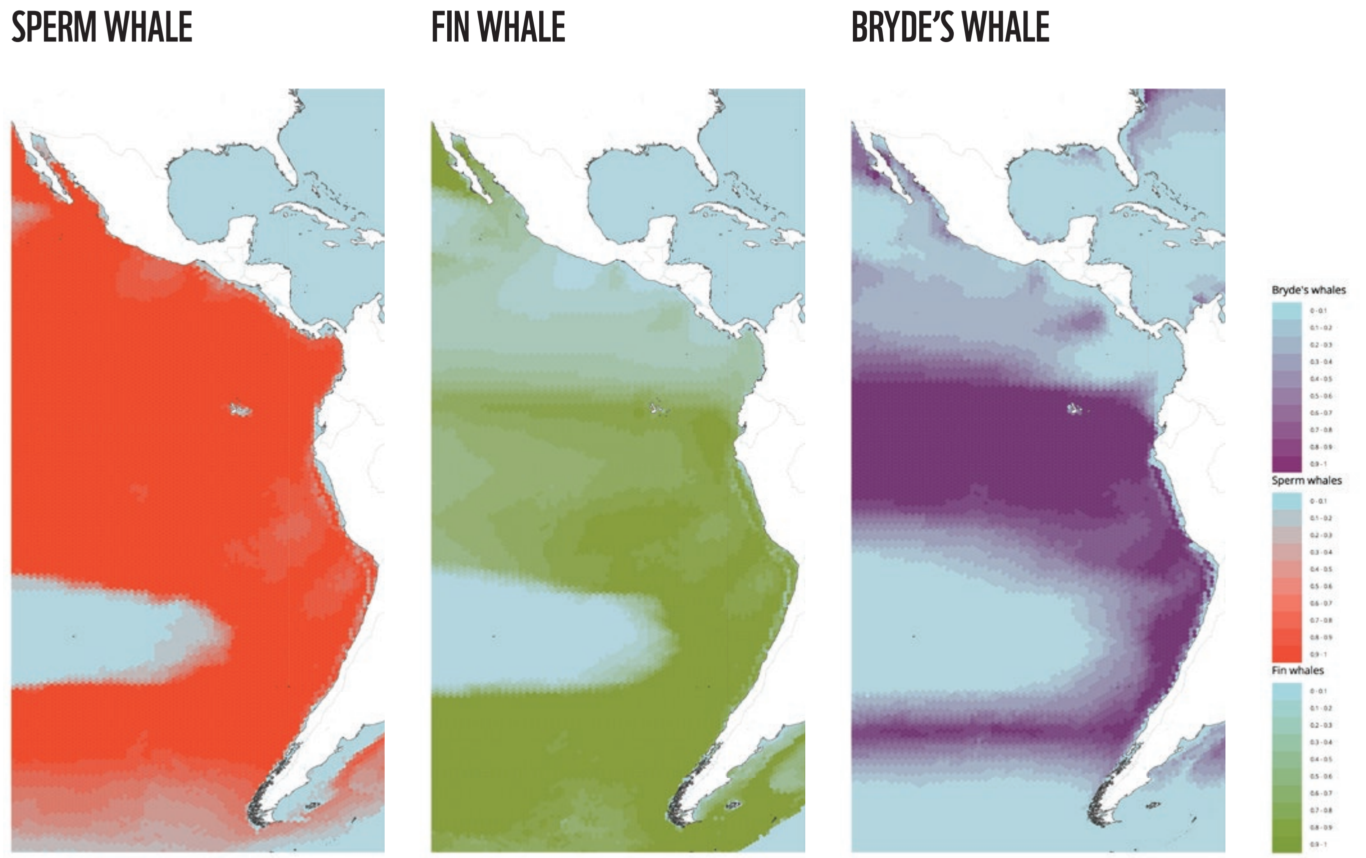


Figure 10: Maps of sperm, fin and Bryde's whale distribution in the eastern Pacific, courtesy of Aquamaps.[26]

CONSERVATION CHALLENGES

Entanglement and mortality in fishing gear, ship strikes and climate change are the main threats to whales in the eastern Pacific. Addressing these problems requires information on ecology, demography and the identification of critical habitat and migration routes. However, data availability is a weakness of the region that cannot be overcome in the short term. Therefore, proactive conservation strategies are required in the face of this knowledge gap. Whales' wide distributions, the inherent difficulties in studying highly mobile animals at sea, and the different threats they face are major challenges for their conservation. Ship strikes and entanglement in fishing gear are challenges for whales in this region.

The IWC has identified Panama as a High Risk Area where humpback whales are at high risk of ship strike.[168,169] In December 2014, the IMO adopted a Traffic Separation Scheme with corresponding inshore traffic zones and seasonal speed limits of less than 10 knots to reduce the whale-vessel strike risk in the Gulf of Panama. Humpback whales are present in the area August to November. Recent analysis shows that compliance varied depending on vessel type using the Traffic Separation Scheme and overall speed compliance was low.[170] In Ecuador, both ship strikes and entanglements in fishing nets have been reported.[171,172]

Along the coast of Peru, whale-watching has increased exponentially in the last 5 to 10 years and there is no formal regulation that can protect mother/calf pairs. A recent study recommends that whale-watching regulations are implemented to regulate number of boats, distance to whales, approximate speed and time observing humpback whales, and that encounters with calves should be avoided. Poor whale-watching practice can initiate short-term behavioural responses including negative impacts from noise pollution emitted by vessels.[173]

Studies of movements and dive behaviour have shown that blue whales within fjords in the northern Chilean Patagonia are at high risk of ship strike in specific areas and at specific times.[174,175] Areas of high risk of ship strike have also been identified in the southern-most part of Chile.[176] In the central-south coast of Chile, two fin whales were found stranded with signs of ship strike.[177]

High density of marine ship traffic occurs between Chiloé Island's inner waters and the Pacific Ocean as well as the channel and fjords from southern Chile through the Magellan Strait, a narrow passage connecting the Pacific and Atlantic oceans in South America. Between 249 and 1,322 vessels navigate this area, with sizes varying between 10 to 200m long. The average vessel speed is between 8.3 and 22.5 knots, where recent studies have identified around 729 active vessels operating per day from the aquaculture industry in this region.[174]

Entanglement and mortality in fishing gear, ship strikes and climate change are the main threats to whales in the eastern Pacific. Addressing these problems requires information on ecology, demography and the identification of critical habitat and migration routes.

HOTSPOT: HIGH-DENSITY DISTANCE WATER SQUID FISHING ALONG THE EDGE OF NATIONAL WATERS

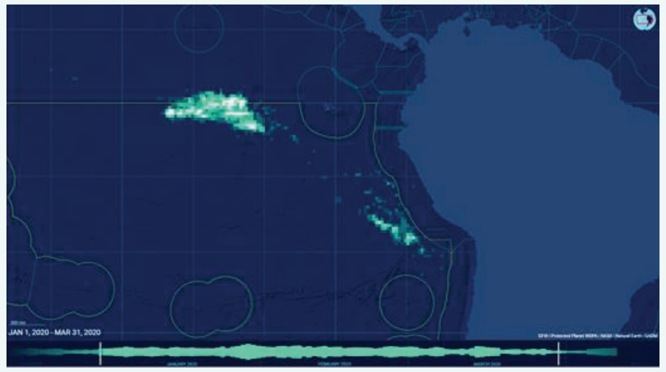
The jumbo flying squid (*Dosidicus gigas*) – also known as Humboldt squid – is the most abundant squid species in the southeast Pacific Ocean. It is subject to one of the most important fisheries in the world extending from the North American coast to southern Chile.[178] High seas management is within the remit of the South Pacific Regional Fisheries Management Organization (SPRFMO), where it is the second largest fishery of this intergovernmental management body.[158]

Between 1990 and 2018, the annual reported catch from the high seas has increased from ~5,000 to ~278,000 tons. Travelling along the coastlines of Ecuador, Peru and Chile, the jumbo squid is of high socio-economic importance to communities throughout the region, not just as a source of food security but for income as well.[179]

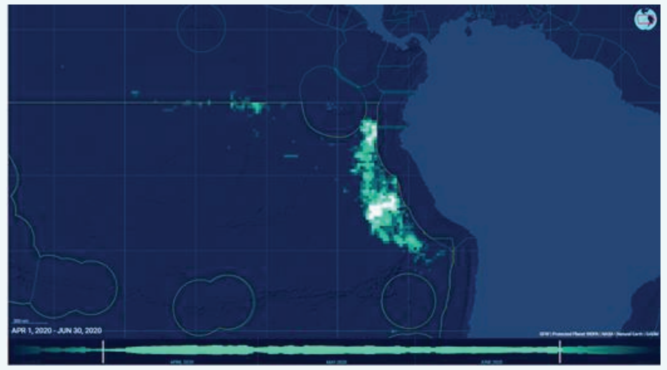
Global Fishing Watch, in support of partnerships with some coastal states in Latin America, used remotely observed satellite data and artificial intelligence machine learning to better understand the extent and activity of the squid fleet operating in the southeast Pacific in 2020.

- The distant water squid fleet comprised 615 vessels that spent a total of 94,559 days fishing from January to December.
- The fleet followed the squid from fishing grounds west of the Galápagos Islands to the high seas north of Peruvian waters and into the Atlantic off the EEZ of Argentina.
- Of the 615 vessels operating in 2020, a total of 95 per cent were flagged to China. The remaining 5 per cent were flagged to Chinese Taipei and the Republic of Korea.
- Irregularities were identified across the distant water fleet including cases of multiple or shared MMSI numbers – identification numbers that are intended to be unique – as well as false positioning, or "spoofing", which occurs when vessel operators broadcast a position outside the footprint of the receiving satellite.

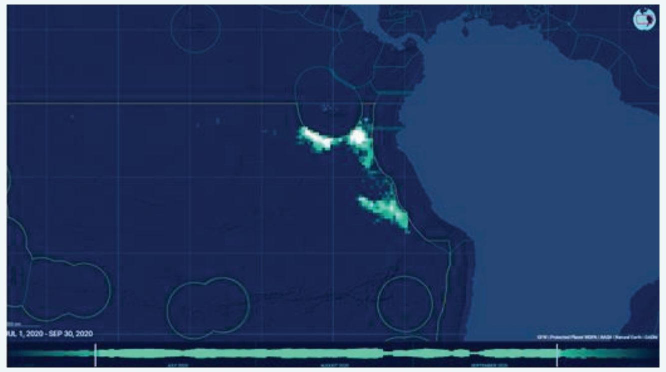
Like whales, squid are migratory and always on the move. This high-intensity squid-fishing effort of this fleet threatens both ecological balance and local livelihoods as squid play an important role in the health of other fisheries and marine ecosystems.[180] Top predators such as such as sperm whales and other toothed whales, tuna, salmon, sharks and billfish rely on squid or fish that eat squid for a significant part of their diet. The high-intensity use of longlines by this fleet means a high risk of incidental capture of species such as sharks, manta rays, sea lions and sea turtles – all protected species.[180]



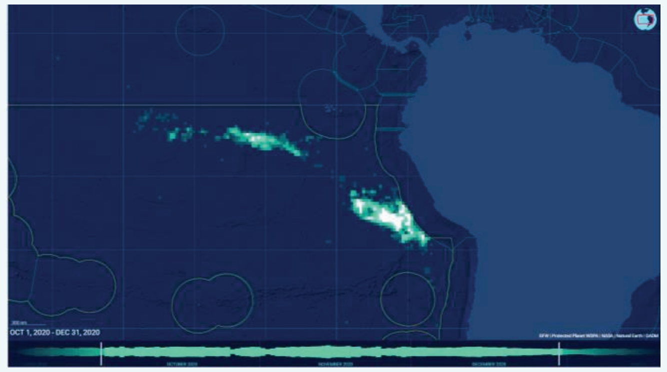
Quarter 1 (Left) (Jan-March) Average: 427 Max: January – 467



Quarter 2 (April-June) Average: 302 Max: April – 338



Quarter 3 (Left) (July-Sep) Average: 355 Max: September – 372



Quarter 4 (Oct-Dec) Average: 436 Max: November – 456

Figure 11: Maps of 615 vessel movements by Global Fishing Watch operating along the edge of South American EEZs.[158]

EASTERN TROPICAL PACIFIC MARINE CORRIDOR (CMAR)

The proposed mega marine protection area will cover more than 200,000 square miles.

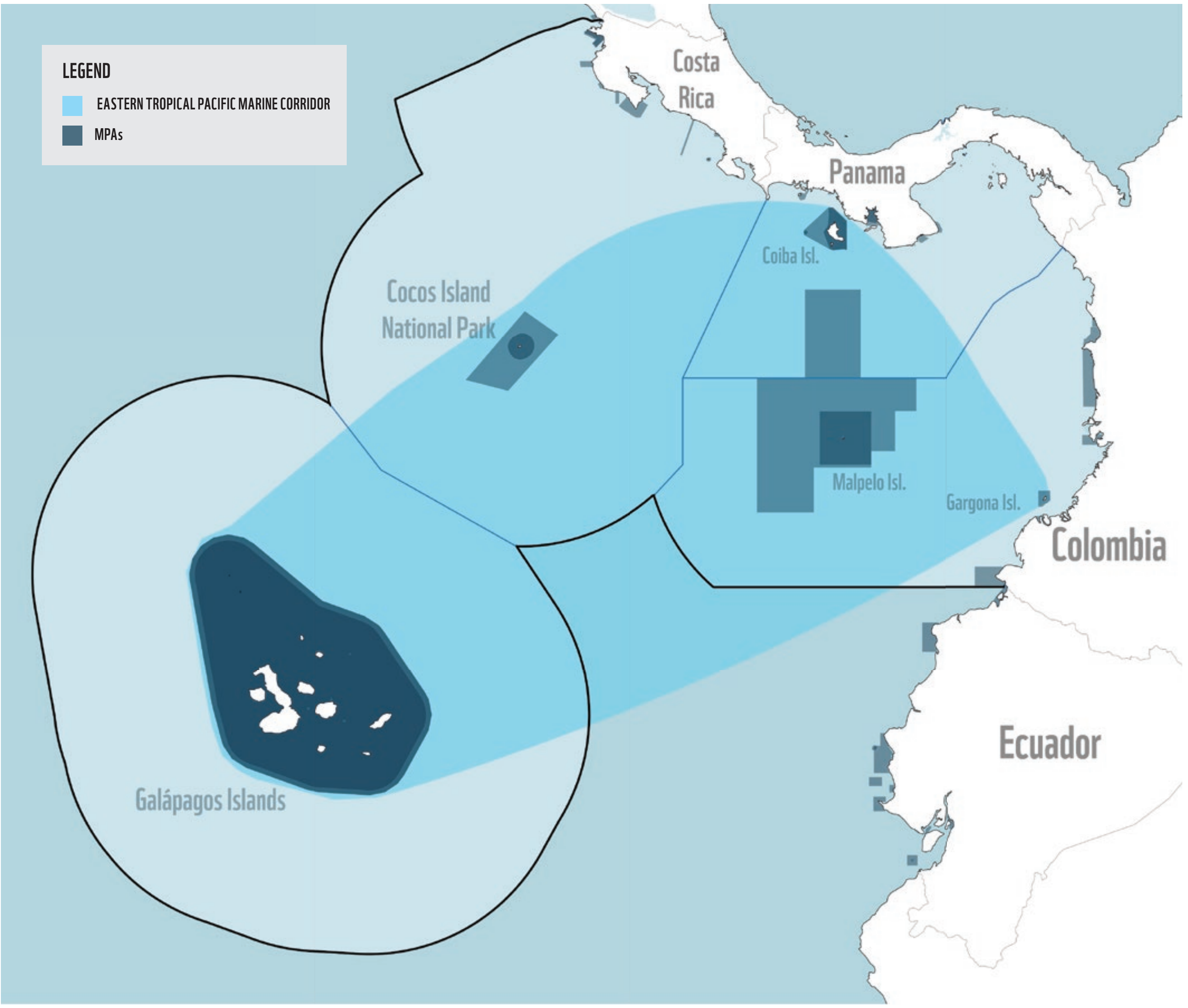
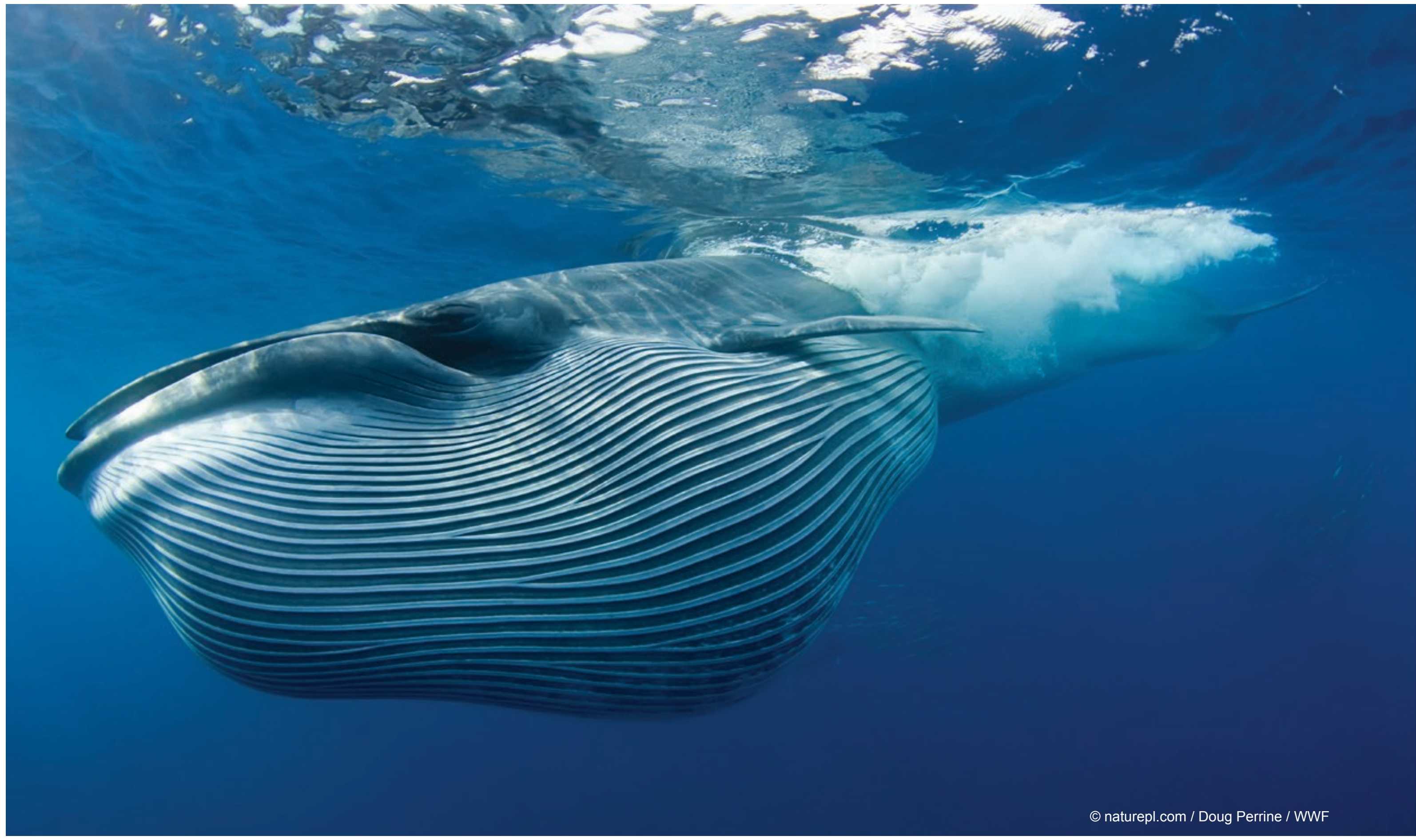


Figure 12: The multinational protected marine corridor covers more than 500,000km² and will help conserve many marine species including cetaceans.



CONSERVATION OPPORTUNITIES AND SOLUTIONS

Protecting areas between critical habitats of marine species with benefits to whales

In November 2021, Panama, Ecuador, Colombia and Costa Rica announced the Eastern Tropical Pacific Marine Corridor (CMAR) initiative, a network of interconnected national MPAs to create a fishing-free corridor protecting more than 500,000km² of critical ocean habitats. It is one of the world's most important migratory routes for whales, sea turtles, sharks and rays. It will help threatened endemic, native and migratory species in the region, including blue, Bryde's and sperm whales along with a range of dolphin species.[181]

This network of marine reserves follows the underwater mountain range that connects Costa Rica's Cocos Island National Park and Ecuador's Galápagos Marine Reserve, both UNESCO World Heritage Sites. These two areas are linked by a 700km underwater chain of seamounts. Many species of marine birds, invertebrates, fish, sharks, sea turtles and whales such as blue whales could benefit from this conservation initiative as it further protects critical habitats in eastern Pacific.[182,183]

It includes a new Galápagos protected area that would be split into two: a no-take zone of 30,000km² to the northeast of the Galápagos Islands connecting Ecuador's waters with those of Costa Rica, along the underwater seamounts of the Cocos Ridge, a key migration route for ocean-going species. Another 30,000km² area is a no-longline fishing zone wrapping northwest around the existing Galápagos Marine Reserve. Marine reserves are well-known strategies to tackle climate change, thus allowing the ocean time to recover and keep offering benefits for humanity.[181,184]

Shifting shipping lanes off the coast of Peru

Peruvian waters are an important area for humpback whales, as they are both a transit and breeding habitats. However, the potential risk of ship strikes is still a non-quantified threat for cetaceans within the Peruvian marine territory.[185] Evidence from neighbouring countries supports the need to address this issue through preventive measures, such as the ordering of marine traffic, especially in the vicinity of breeding grounds in northern Peruvian waters.[168]

Shipping routes in the southeast Pacific often overlap with whale habitat, either during the breeding season[168] or during migration.[186] This overlap, in addition to the speed of the shipping vessels, puts whales at risk of harmful collisions and it has received little attention in conservation management.[185] Due to projections of the region's trade growth with East Asian countries, researchers predict an increase in maritime traffic density in the near future, with the consequent increase in the probability of ship strikes.

Three Traffic Separation Schemes within the jurisdictional waters of Peru are being proposed to help reduce ship strikes. This system would be recommended for use by all vessels, after being adopted by the IMO, with the exception of national vessels engaged in fishing, hydrocarbon and tourism activities that have the corresponding permit granted by the government of Peru, through its competent entity, and areas established for the activity.

With the understanding of the importance of the Peruvian coastline in the seasonal migration of humpback whales and the potential risk of human activities on their breeding grounds, the implementation of routing measures for whale conservation is necessary considering that this region is important habitat for eight species of large cetaceans.[187] These include blue whales, fin whales, sperm whales and southern right whales (*Eubalaena australis*). The latter is of particular concern, as the Chile–Peru subpopulation of southern right whales is Critically Endangered according to the IUCN, with less than 60 remaining adults, whose main threat is mortality due to ship collisions.[188]

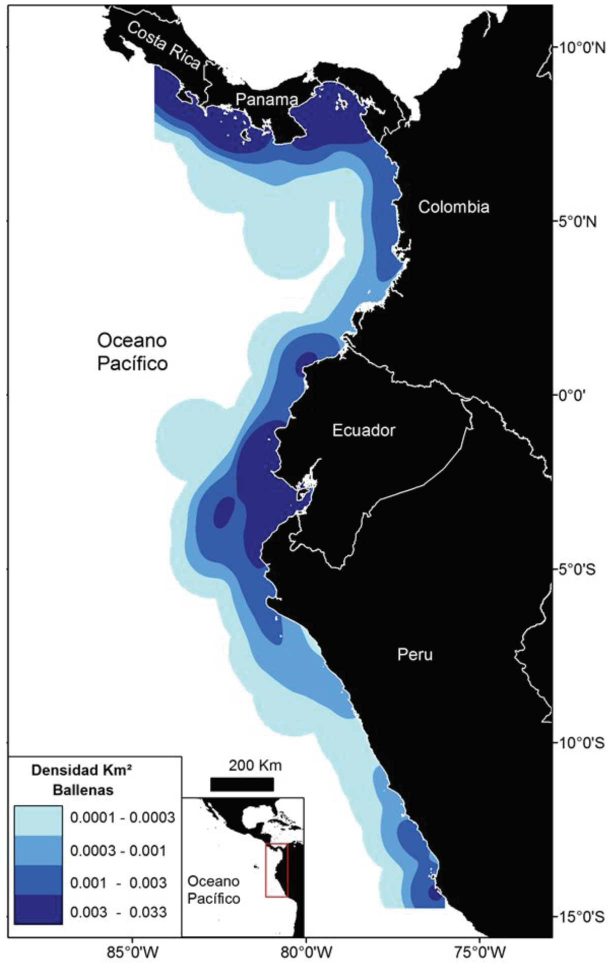


Figure 13: (Left) Density distribution of humpback whales in Peruvian waters with core areas of high density (dark blue) between Manta (Ecuador) and Isla Lobos (Peru).[189]

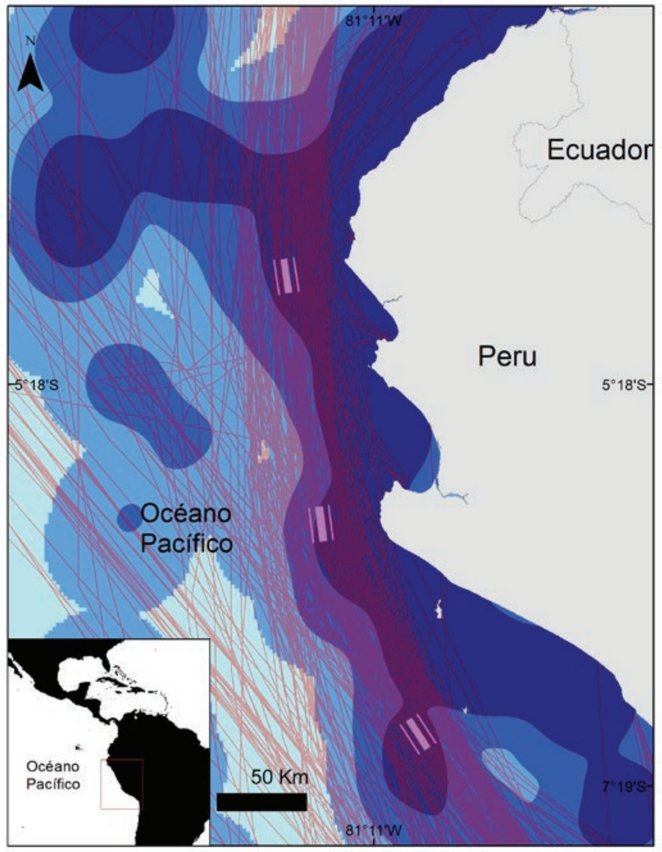


Figure 14: The Traffic Separation Scheme proposed for the Pacific Coast of Peru is defined in the light red areas with the lines showing vessel traffic.[189]

Taking a multi-policy approach to protect migration

Most of the countries in the region are signatories to the main international conventions related to the conservation and sustainable use of marine resources. They also have developed a regional institutional framework through binding instruments, particularly in the southeast Pacific. Despite this, institutional weaknesses both nationally and regionally persist. Several action plans for species such as humpback and blue whales have been developed, as well as networks of MPAs that promote marine management through capacity building, scientific research and promoting the exchange of experiences. However, in many cases these plans are out of date and require review and strengthening.

Notwithstanding these deficiencies in the conservation of great whales, regional institutionalism constitutes an opportunity. In the southeast Pacific there is a specialized maritime agency, the Permanent Commission of the South Pacific (CPPS), which is, among other things, the technical secretariat of the United Nations Environment Programme's Action Plan for the Conservation of Marine Mammals in the Southeast Pacific, a management instrument created specifically to promote the conservation of these species and their habitats. There is no such specialized regional institution in Central America nor an action plan for marine mammals, but other national or regional institutions could assume that role.

Several initiatives in the region are aimed at strengthening the management of MPAs and migratory species, such as the CMAR and the UNESCO World Heritage Sites and Biosphere Reserves. In 2012, the CBD Secretariat led a scientific process to describe 21 EBSAs in the eastern tropical Pacific. In 2021, IUCN specialists and experts from the region will conduct a similar process to describe IMMAs in the eastern Pacific.

CASE STUDY: PROTECTING CRITICAL OCEAN HABITATS IN SOUTHERN CHILE WITH INDIGENOUS COMMUNITIES

In recent years, Chile has protected a significant area of the country's EEZ (42.4 per cent). However, only 5 per cent is in coastal areas. In the Chiloé Marine Ecoregion in southern Chile, only 0.11% of this critical habitat is managed or protected.

In 2008, the Chilean government created a category of protected areas called Native Peoples' Marine Coastal Spaces, known by the Spanish abbreviation ECMPOs. These are coastal and marine areas designated by the government's Undersecretary of Fisheries and Aquaculture (SUBPESCA) and loaned to Indigenous groups to use and administer.

Over the last decade, WWF-Chile has worked to identify and advocate for effective management of MPAs including working with Indigenous communities in Chiloé and Guafo Islands.[190]

Currently, 11 Mapuche-Huilliche communities on Chiloé Island have created and administer the Wafo Wapi Coastal Marine Area of Guafo Island, located 40km southeast of Chiloé Island. This area is recognized for its high biological productivity, great ecological value and presence of highly migratory, emblematic and endangered marine species, such as the blue whale. The blue whale holds great cultural value for Mapuche-Huilliche communities, which regard this species as a ferry that transports their ancestor spirits around the island waters. The protected area consists of the entire coastal marine area, from the coastline to 12 miles around the island, and covers 299,000km².

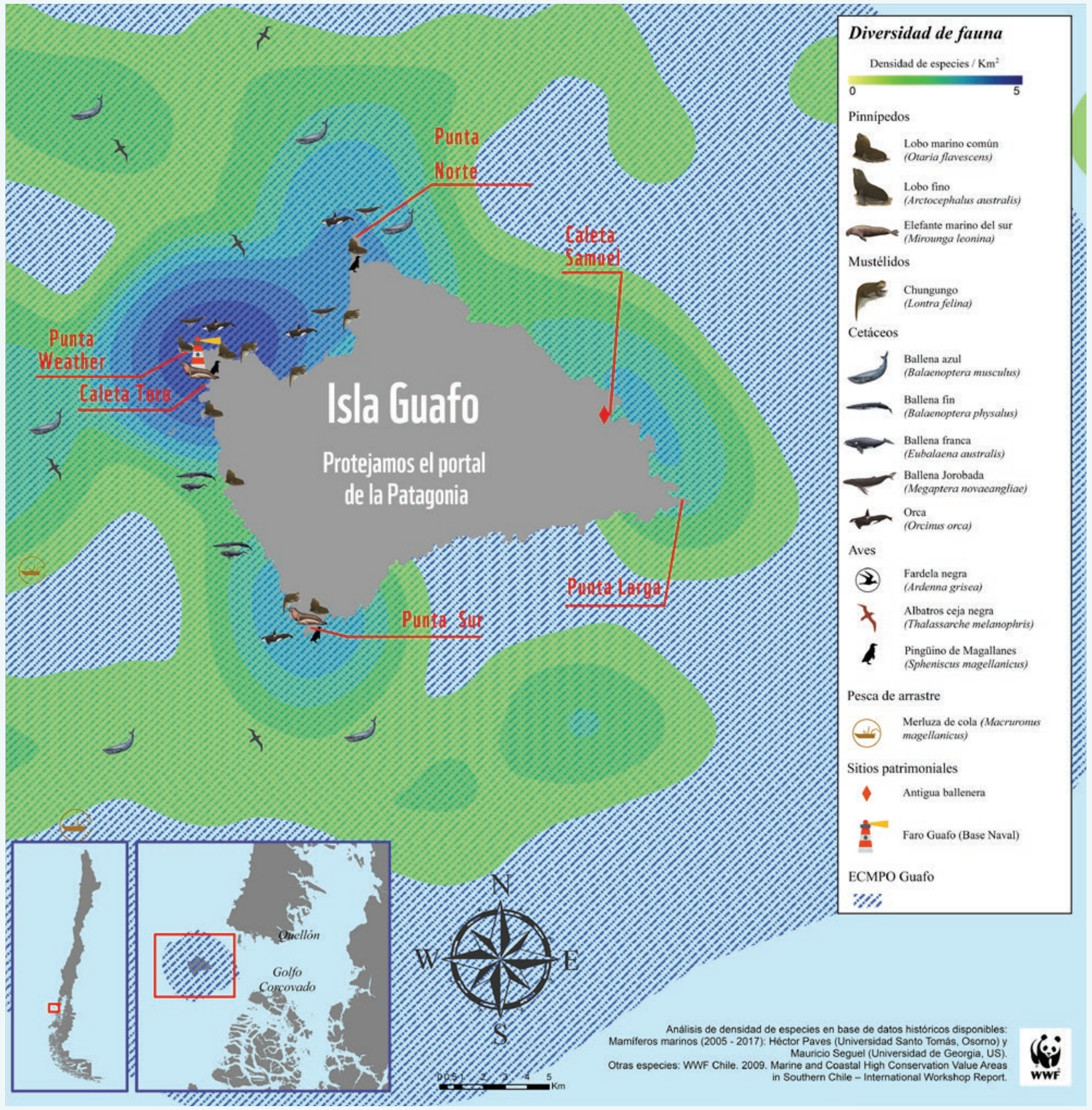


Figure 15: Marine biodiversity found around Guafo Island including important habitat for blue whales.

CONSERVATION OPPORTUNITY: PROVIDING REAL-TIME INFORMATION FOR MARINERS NAVIGATING THE CORCOVADO GULF, CHILE

The Corcovado Gulf is an important feeding ground for migratory blue and humpback whales in Southern Chile. Since 2017, WWF-Chile has been working in collaboration with researchers from COPAS SUR-Austral from Concepción University and Woods Hole Oceanographic Institution to understand and reduce the impact of noise pollution on whales as well as design a real-time acoustic warning system for vessels to prevent ship strikes in the region.

Deploying Slocum gliders (an autonomous underwater vehicle), researchers have tested real-time acoustic detection methods to alert vessels to reduce their speed when whales are in the area. Recently, researchers have been testing a year-round mooring system as a more permanent tool. They are also working with maritime transport companies to identify the best methods to alert mariners to reduce navigational speed to less than 10 knots during whale foraging season.

Photo: A Slocum underwater glider. Photo courtesy of Woods Hole Oceanographic Institution.

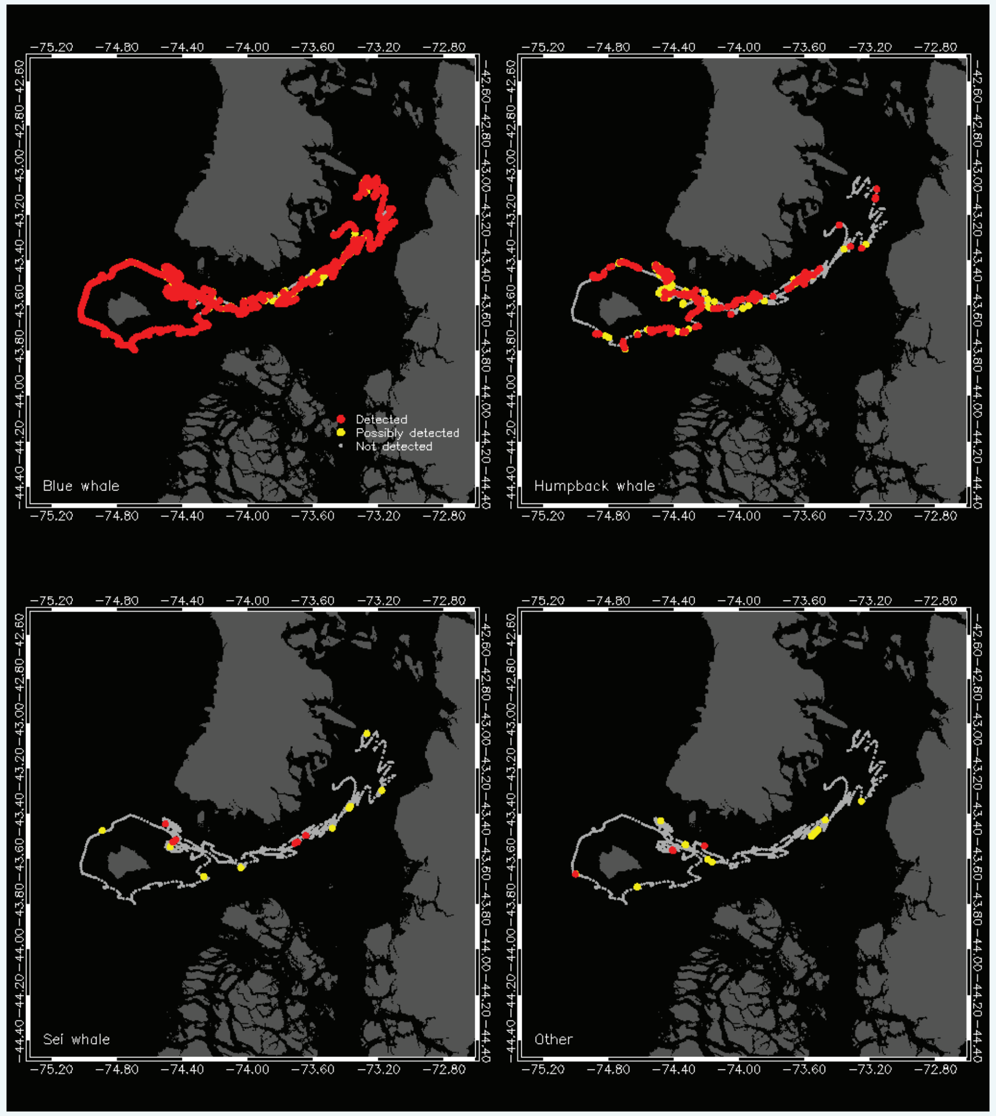


Figure 16: The path of a Slocum glider detecting vocalisation of marine species such as blue, humpback and sei whales.

REGIONAL SEAS AGREEMENTS

Improving policies to better protect important habitats and corridors for migratory whales will require harmonization of efforts by regional policy agreements to address multiple threats. Examples include the following:

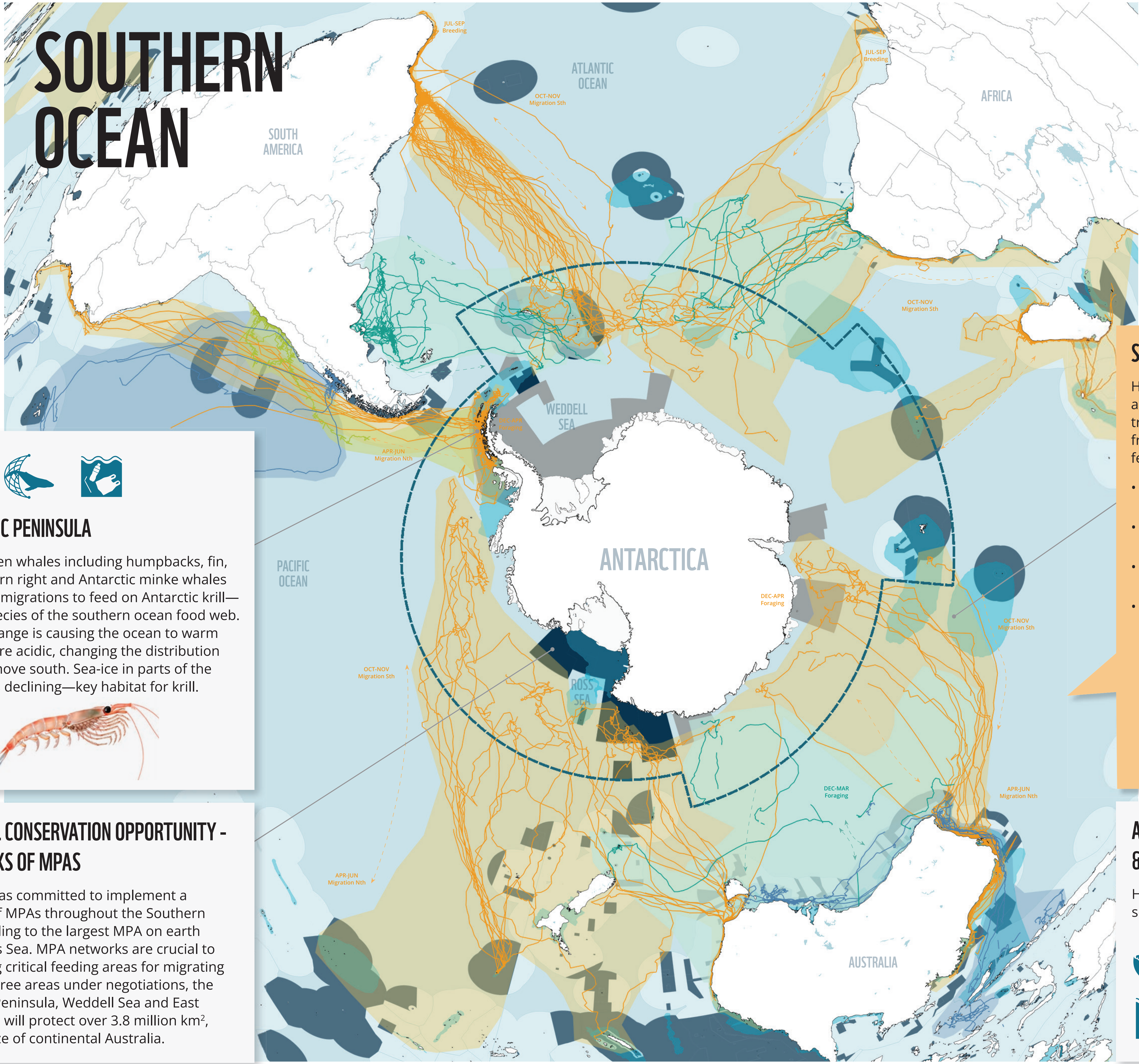
Permanent Commission of the South Pacific (CPPS):

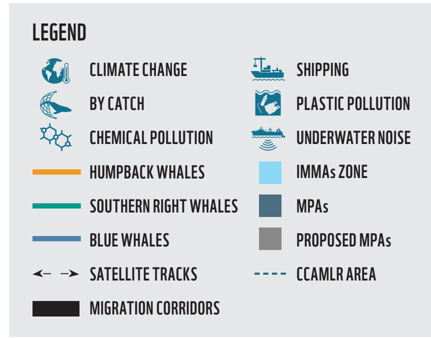
The CPPS was established in 1952 by Ecuador, Chile and Peru. Colombia joined in 1978. CPPS is a regional maritime system dedicated to the coordination of maritime policies with an emphasis on science, legal affairs and environmental issues. Within the framework of CPPS, countries have adopted a series of binding agreements and conventions related to the exploitation and conservation of fishery resources, including whales. In its beginnings, the CPPS was a regional fisheries body that regulated whaling based on the recommendations of the IWC to guarantee the sustainability of cetacean stocks in the region (mainly baleen whales and sperm whales). CPPS coordinates regional programmes through regional groups of experts in different matters.

Convention for the Protection of the Marine Environment and the Coastal Zone of the Southeast Pacific (Lima Convention):

The Lima Convention was adopted by Chile, Colombia, Ecuador, Panama and Peru in 1981. The objective of this regional cooperation mechanism is the protection of the marine and coastal environment to safeguard the health and well-being of current and future generations. Through the Lima Convention, countries agreed to adopt appropriate measures to prevent, reduce and control pollution of the marine environment and the coastal zone of the southeast Pacific and to ensure adequate environmental management of natural resources. The CPPS serves as its Executive Secretariat. The Lima Convention through its Action Plan is part of the Regional Seas Programme of the UN Environment. The Coordination office of the Southeast Pacific Plan of Action also acts as the technical secretariat for the Plan of Action for the Conservation of Marine Mammals of the Southeast Pacific.[191]

SOUTHERN OCEAN





Whale illustrations © Uko Gorter

ANTARCTIC PENINSULA

Many baleen whales including humpbacks, fin, sei, southern right and Antarctic minke whales make long migrations to feed on Antarctic krill—the key species of the southern ocean food web. Climate change is causing the ocean to warm and be more acidic, changing the distribution of krill to move south. Sea-ice in parts of the Antarctic is declining—key habitat for krill.

A GLOBAL CONSERVATION OPPORTUNITY - NETWORKS OF MPAS

CCAMLR has committed to implement a network of MPAs throughout the Southern Ocean adding to the largest MPA on earth in the Ross Sea. MPA networks are crucial to conserving critical feeding areas for migrating whales. Three areas under negotiations, the Antarctic Peninsula, Weddell Sea and East Antarctica, will protect over 3.8 million km², half the size of continental Australia.

SOUTHERN HUMPBACK HIGHWAYS

Humpbacks undertake one of the world's great animal migrations. Every year, they make round trip journeys swimming thousands of kilometres from tropical and subtropical breeding areas to feeding areas in the Southern Ocean and back.

- 367 humpbacks tracked via satellite tags by scientists.
- On their migrations, these whales passed through the national waters of 28 countries.
- 52% of locations were in international waters, beyond the jurisdiction of any country.
- The longest of these tracks was ~18,942 km, over 265 days, from the animal's summer foraging area near the Antarctic Peninsula, up to its winter breeding area off Colombia and back to the Antarctic Peninsula.

ATLANTIC, INDIAN, PACIFIC & SOUTHERN OCEAN

Humpbacks face multiple threats on their long, seasonal migrations crossing oceans.

SOUTHERN OCEAN

© Duke University Marine Robotics and Remote Sensing Lab

Historically, the waters around Antarctica supported diverse and abundant baleen and toothed whale communities. Antarctic blue whales are the world's largest living animal, with lengths up to 33.6m, and have a continuous circumpolar distribution around the continent.[192]

In the austral summer, Antarctic blue whales feed almost exclusively on euphausiids (krill), especially Antarctic krill,[193] predominantly near the edge of the pack-ice zone. Listed as Critically Endangered by the IUCN Red List of Threatened Species, the population is less than 3 per cent of its level of three generations ago (at least a 97 per cent decline).[194] Antarctic blue whales are found in the region year-round, albeit with greatly reduced populations in winter months.[195]

Relatively high densities of fin whales – the second-largest animal on the planet – are found in oceanic waters near the South Shetland Islands.[196,197] Likewise, the northwest portion of the Bransfield Strait and Scotia Sea contains increasing numbers of fin whales. More than 12,000 fin and 9,000 blue whales were killed in continental waters in the 1920s; relatively few fin whales and no blue whales are now found in these areas. With respect to blue whales, a small number of sightings are made annually from ships in the Drake Passage and concentrations of fin whales are often noted offshore of Boyd Strait.

Antarctic minke whales are also relatively common around the Antarctic continent. Although highest densities are associated with the marginal/seasonal ice edge, minke whales inhabit the nearshore bays along the western side of the Antarctic Peninsula routinely. Their numbers are much lower in more open waters and exposed areas, in part due to predation risk from killer whales. North (in the

© National Geographic Creative / Robert Harding Picture Library / WWF

Weddell Sea) and south of the Antarctic Peninsula, minke whale densities are likely to be higher in areas with more persistent and extensive sea-ice cover.

Baleen whales depend on krill for survival. Krill are small, semi-transparent crustaceans and a vital component of the Antarctic ecosystem. They are a main source of food for many mammals such as seals and whales, as well as birds and fish.[198] There are around 380 million tonnes of these shrimp-like crustaceans in the Southern Ocean, similar to the total weight of human life on the planet.[199] They live for about seven years and are no larger than a little finger. Past studies indicate that krill survival and lifecycle are directly linked to fluctuations in sea ice and have already revealed a decline in krill abundance.[200] Long-distance migrants, such as humpback whales, occur disproportionately in higher latitudes where the speed and magnitude of climate change are the greatest. They are particularly vulnerable to the detrimental impacts through changes in habitat and prey availability and mismatches in timing of migration.[201]

Across their range, fin, humpback and minke whales are known to be generalist feeders whose diet includes krill and schooling fish. However, around the Antarctic Peninsula – and Antarctica as a whole – their diet mostly comprises Antarctic krill. As well, blue whales are obligate krill feeders, and their diet reflects this in the Antarctic. Southern right whales are known to feed on copepods and krill throughout their range but around the Antarctic they eat mainly krill. Because of the enormous biomass of krill relative to other potential prey items in the region, Antarctic krill are critical to baleen whale foraging success and population growth.

Humpback distribution is best predicted by the distribution of Antarctic krill and proximity to the coast.[202–206] The seasonal movement patterns of the whales likely reflects that of krill: humpback whales are broadly distributed across the continental shelf in the summer and then move inshore to the straits and coastal bays in the autumn.[205,206] By autumn, the whales spend more time feeding, less time transiting[207,208] and their home ranges become much smaller.

ANTARCTIC PENINSULA

The Antarctic Peninsula is an important foraging area for whale species including humpback, minke, fin, southern right and blue whales.[209] Here, they feed on Antarctic krill, their main prey in the Southern Ocean.

During summer months, whales generally feed in the upper 100 metres, and in autumn between the surface and as deep as 400 metres.[207,208,210–212] Recovering humpback whale populations require lots of krill, but this is potentially in conflict with human demands for krill.

The Gerlache and Bransfield Straits along with the adjacent bays (e.g. Wilhelmina, Andvord and Flandres) are the most important feeding areas for baleen whales around the Antarctic Peninsula.[208,213,214] These areas are used throughout the summer and become the exclusive feeding habitat in autumn as sea ice develops and krill move inshore in autumn.[205,206] For example, in one day, more than 500 humpback whales and 2.3 million tonnes of krill were measured in Wilhelmina in May 2009.[214,215] Feeding behaviour is spatially and temporally clustered as krill are not uniformly distributed. Tagging studies and surveys have shown high concentrations of whales in May and June and animals remaining around the peninsula into July.[206,212]

CONSERVATION CHALLENGES

20th-century commercial whaling

During the 20th century, unchecked commercial whaling dramatically reduced whale populations throughout the Southern Ocean, driving many species to the brink of extinction. The international community has long-since recognized the importance of protecting whales in the Southern Ocean, with the IWC specifically prohibiting commercial whaling through a moratorium on commercial whaling in 1982 and the establishment of the Southern Ocean Whale Sanctuary in 1994.

More than 2 million whales were commercially harvested to near extinction in the southern hemisphere,[15,216] including blue, fin, right, humpback, sei, minke and sperm whales taken from oceanic and coastal waters. Throughout the Southern Ocean, more than 725,000 fin, 400,000 sperm, 360,000 blue, 200,000 sei and 200,000 humpback whales were killed during this time.[15]

A changing climate

According to the recent Special Report on the Ocean and Cryosphere in a Changing Climate from the United Nations Intergovernmental Panel on Climate Change,[40] climate change is transforming the Antarctic in lasting and fundamental ways.[40] Antarctic ice shelves have shrunk in size by almost one quarter since the 1950s[217] and the continent has lost an astounding 3 trillion tonnes of ice since 1992,[217] similar to the weight of water needed to fill 1.2 billion Olympic swimming pools.

Antarctic marine ecosystems are also undergoing rapid, unprecedented transformation. Projected warming, ocean acidification, reduced seasonal sea-ice extent and continued loss of sea ice directly and indirectly affect wildlife habitats and populations. Sea ice is critical habitat for Antarctic krill, a key prey species for penguins, seals, fish and whales.[52]

Migrating south from Australia to forage on krill, humpback whales contend with rapidly changing environmental conditions influenced by climate change, ocean warming and ocean acidification that are shifting prey distributions.[216] Modelling predicts that suitable krill habitat, as well as krill populations, will shift southward by the end of the 21st century.[52,218]

For baleen whales feeding almost exclusively on krill – such as humpbacks, fin, Antarctic blue and Antarctic minke whales – these southward shifts in krill distribution may impose high energetic costs on migrating whales, with effects on body condition, reproductive fitness and population abundance.[53]

The Western Antarctic Peninsula is a hotspot of global environmental change. Climate change is having an increasing impact, warming the ocean and causing it to become more acidic.[219]

Growing commercial krill fishing

Historically, commercial krill fishing occurred around the entire continent of Antarctica. This led to the establishment of CCAMLR in the 1980s.

Currently, CCAMLR does not include information on climate change or fine scale krill distribution in its assessment of risks to manage krill fisheries. Whales are delegated to management under the IWC and are not considered in ecosystem-based management decisions related to commercial fishing and long-term monitoring under the CCAMLR Ecosystem Monitoring Program (CEMP) – which is an important program for monitoring potential negative impacts of fishing on local predators. WWF and others have called for the program to be modernised so that it includes whales and seals as part of its future monitoring and management efforts.[209] There are opportunities for greater knowledge exchange and formal collaboration with the IWC as extensive datasets are now available for CCAMLR.

In recent years, krill fishing has primarily taken place in the Antarctic Peninsula and Scotia Arc where catches are increasing in critical habitats for eastern Pacific humpback whales. Commercial krill fishing is the largest in the southern hemisphere. Unlike most of the world's large fisheries it has scope to expand[200] and could become the largest fishery of any type.[220] Since 2017, there has been more exploratory krill fishing by China and Norway in East Antarctica (CCAMLR fishing areas 58.4.1 and 58.4.2).

Commercial krill fisheries that operate in the Antarctic Peninsula overlap with important humpback whale foraging areas, increasing risks of bycatch and competition for krill.[206,221]

The Antarctic krill fishery, with a total 2020 catch of 450,000 tonnes, currently operates without fine-scale information on whale movement, behaviour and prey requirement.[222]

Photos: The Aker BioMarine krill fishing vessel – Antarctic Endurance, a Norweigan flagged ship – was photographed actively trawling towards and through a large group of fin whales 25 km north of Coronation Island on 13 January 2022. There were estimated to be between 500 and 1200 fin whales, with some blue and humpback whales in this aggregation. At the 2021 CCAMLR meeting, it was reported that humpback whales were killed as bycatch by industrial krill fishing operations by Norwegian vessels. Scientists and WWF are calling for a review of krill fishing practices as there are increasing concerns of whale, seabird and seal bycatch that may be underreported.[433] Photos © Conor Ryan.

CONSERVATION OPPORTUNITIES AND SOLUTIONS

A Southern Ocean network of MPAs – helping the recovery and conservation of whales

The Southern Ocean covers 10 per cent of the world's ocean and includes some of the most productive marine areas in the world.

In protected areas of the ocean, activities are managed, limited or entirely prohibited. Antarctic ocean life is conserved through coordinated international management by CCAMLR, which can make binding consensus decisions about controlling the use of marine living resources.

CCAMLR has committed to the creation of a representative system of MPAs throughout the Southern Ocean.[223] Implementing effective MPAs will help conserve important Antarctic biodiversity including whales. They can also be used as a reference area to help monitor and understand the effects of fishing outside these regions, as well as the impacts of climate change on the Antarctic ecosystem.

Improving spatial distribution and management of the krill fishery

The fishery for Antarctic krill is managed by CCAMLR under an ecosystem-based framework according to which fishing should not interfere with the population growth of Antarctic krill predators.[224] Nonetheless, potential competition between fisheries and krill predators, including baleen whales, is concerning.[221,225–228] Krill catches have become more concentrated,[221,229] raising concerns about how local depletion of krill impacts predators.[221,228] CCAMLR recognized that this necessitates a smaller-scale management approach and designated "Small Scale Management Units" (16,000km² to 440,000km²). However, catches are still managed in the much larger "Subareas" (658,730km² to 1,033,248km² for Subareas 48.1-48.4).

Consequently, there is a mismatch between the spatial and temporal scale at which krill fisheries are currently managed, and that at which fisheries operate and predators forage. There is a clear and urgent need to better understand potential interactions between baleen whales and the krill fishery. This involves understanding the dynamics and typical spatial scales, both of foraging whales and fishing vessels, implementing the Antarctic Peninsula MPA to reduce interactions.

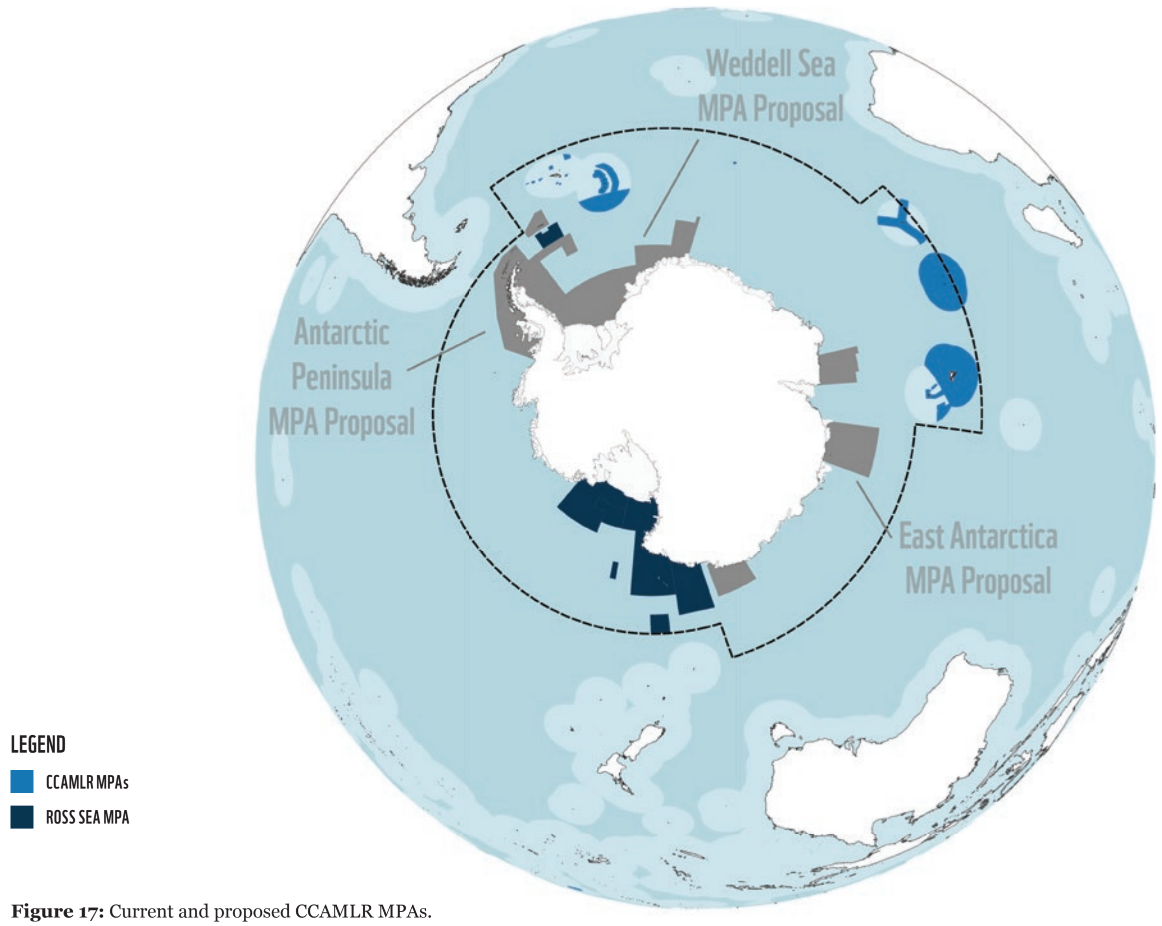


Figure 17: Current and proposed CCAMLR MPAs.

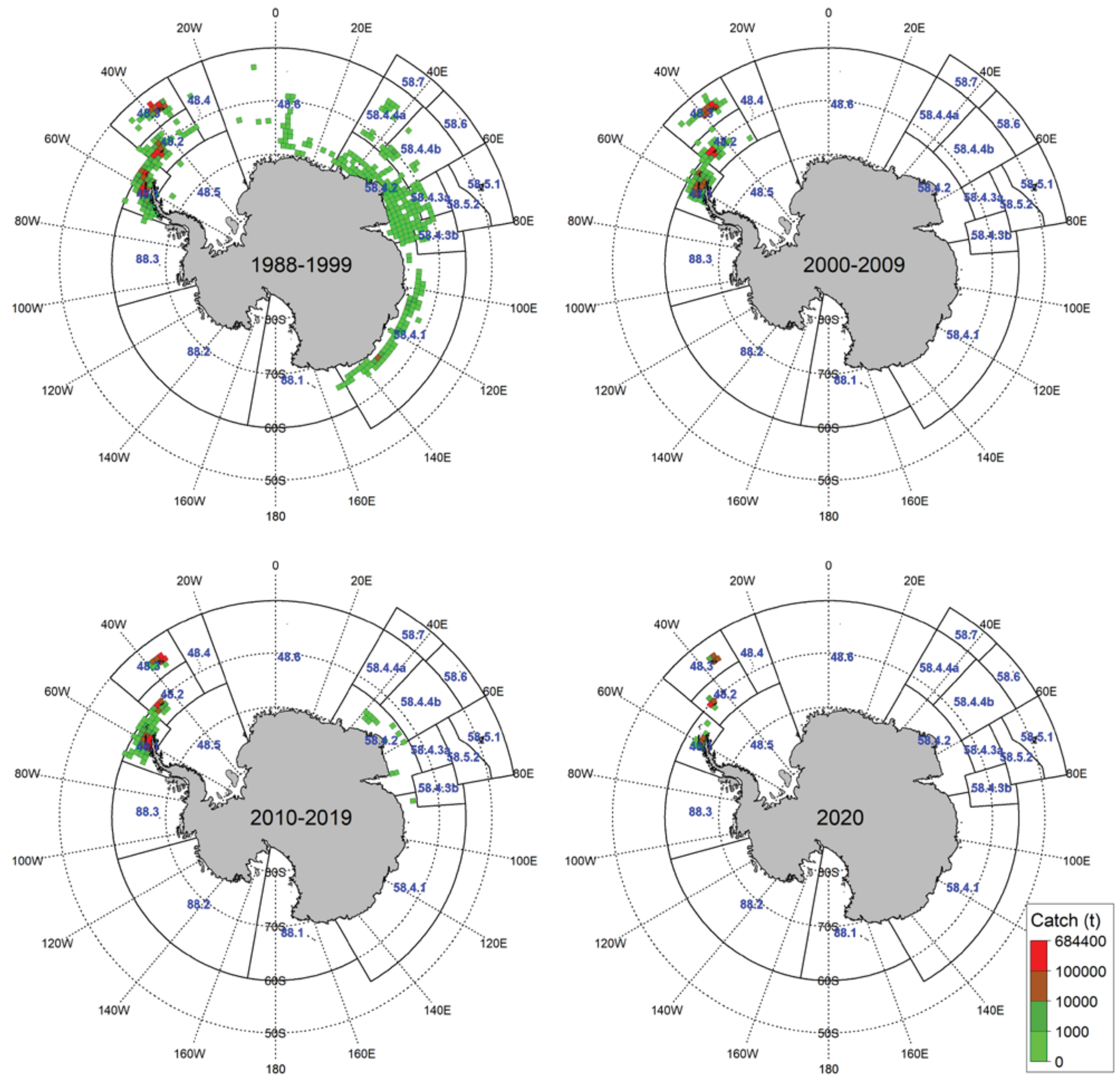


Figure 18: Historical krill fishing.[222]

New technologies to uncover the lives of whales

New technologies are allowing us to study whales and the ocean in new ways. Over recent years, WWF has supported field work such as using digital tags and drones to better understand how and where whales feed to uncover their favorite hotspots along the Antarctic Peninsula.[209] It gives us a window into their world, to understand the health of populations, how they are affected by climate change, and how we might protect their critical ocean habitats worldwide.

Marine conservation that makes a difference takes collaboration. Long-time science partners from University of California Santa Cruz (UCSC) and Duke University Marine Robotics and Remote Sensing Lab (MaRRS) with others from Stanford University published new research in the journal Nature.[3] Using this new toolbox of technologies, including over 300 digital tags the size of an iPhone with suction cups, they analyzed an array of information on baleen whales such as blue, fin, humpback and minke whales. Baleen whales feed by gulping a large amount of water and filtering it through their mouths' fringed baleen plates until only their prey remains. It turns out, an individual blue whale eats an average of 16 tons of food every day — about three times more than scientists had thought.[3]

One area of focus was on the Southern Ocean. Here, baleen whales devour up to 30 percent of their body weight in krill each day. Previous estimates suggested baleen whales consume less than 5 percent of their body weight daily.[3]

Importantly, after all of this eating, comes pooping. Recently, scientists have realized that this helps fertilize our oceans and boosts the growth of phytoplankton, tiny life forms at the bottom of the marine food web that are eaten by krill. It's another example of the important relationships and dependencies between predator and prey.

Researchers feel that if we restore whale populations to pre-whaling levels, we'll restore a huge amount of lost function to ocean ecosystems. It's helping nature help itself, and all of us who depend on it.[230]

Photo (Left): Studying humpback whales with drones and digital tags along the Antarctic Peninsula.

AUSTRALIA

The commercial whaling ban of the 20th century has been critical to allow some whale populations to recover in Australian waters including humpback, southern right and pygmy blue whales.[231] However, the southern right whale population in southeast Australia has been slow to recover[232] and still little data exists for cetaceans who rely on offshore areas off the continental shelf including sperm and beaked whales.[233]

A major contributor to conservation is the Australian Whale Sanctuary[234] under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) which protects all cetaceans (whales, dolphins and porpoises) in the region. Although protected, Australia's whale highways are becoming increasingly complex and dangerous to navigate and require new thinking to management approaches across their entire range.

CONSERVATION CHALLENGES

Increased ship traffic

Growing industrialisation within important whale habitats could spell trouble for Australia's whales. An ever-expanding fleet of ship traffic from supertankers to cargo vessels in seasonal humpback breeding grounds and along migration routes are increasing risks of ship strikes and underwater noise pollution. Within Australian waters, shipping activity has grown by about 4% a year since the early 2000s. Much of this growth has been in the Coral Sea linked to increasing exports of natural resources and has been in areas that are significant for marine mammals, including the Great Barrier Reef (GBR) World Heritage Area.[235] Recent research here found female humpback whales with a dependent calf had a higher risk of ship strikes and their inshore movement and coastal dependence later in the breeding season increases their overlap with ship traffic. Currently, the whale Protection Area in the GBR Marine Park does not cover the main mating and calving areas and researchers have recommended establishment of a Special Management Area during the peak breeding season in high-risk areas.[236]

In the GBR, their breeding grounds overlap with a shipping route that services all ports on the Queensland coast – a situation that has the potential to cause masking of their song.[237] Because of coastal development and port expansions related to the mining industry, UNESCO is monitoring Australia's commitment to the sustainability of the GBR as a World Heritage Area.[235]

Increased risk of bycatch

Recent research and spatial mapping of the historical and modern records highlight entanglement hotspots along the east and west coast of the continent, regions where high human population density, high fishing effort and high density of migrating humpback whales all occur.[238] For humpbacks, fishing nets and shark nets have been identified as posing the greatest risk, although there are inherent challenges in obtaining large-scale anthropogenic interaction data with far-ranging migratory pelagic species that can cross multiple jurisdiction boundaries.[238] In an assessment of entanglements off the Western Australian coast, humpback whales were the dominant species involved in >90% of entanglements with the West Coast Rock Lobster Managed Fishery - a rope-based fishery that occurs in their migratory pathways.[239,240]

Growing interest to expand krill fisheries operations in East Antarctica

Since 2017, there has been more exploratory krill fishing by China and Norway in East Antarctica (CCAMLR fishing areas 58.4.1 and 58.4.2) in areas where Australian humpback whales subpopulations are migrating to feed.

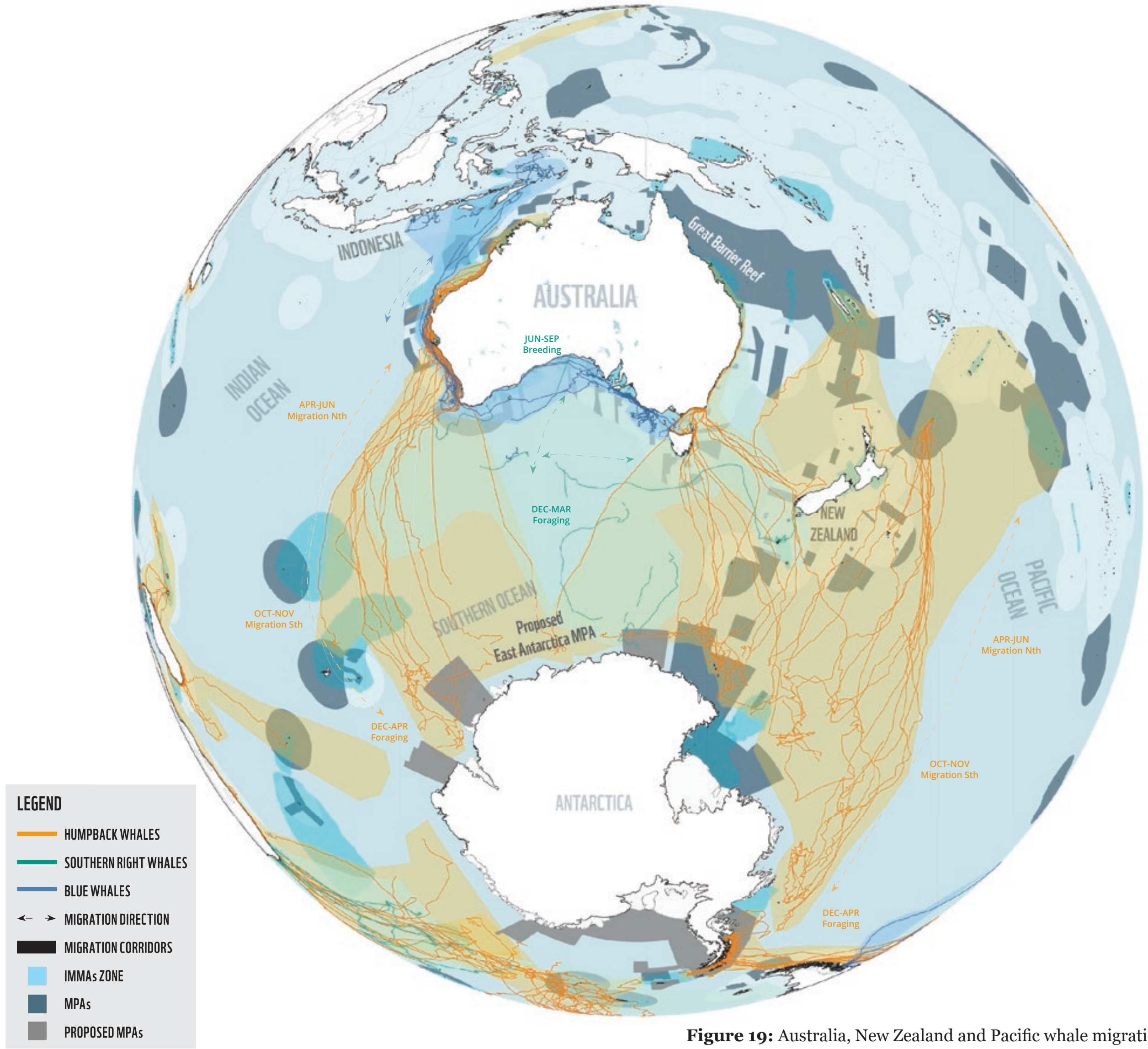


Figure 19: Australia, New Zealand and Pacific whale migrations for humpback, blue, and southern right whales.

Currently, CCAMLR does not include information on climate change or fine scale krill distribution in its assessment of risks to manage krill fisheries. Australian Antarctic Division is currently undertaking krill research in this area.[241]

Additional threats along humpback whale migration routes globally include oil and gas development[242,243] and pollution.[16]

CONSERVATION OPPORTUNITIES AND SOLUTIONS

Reinvigorate financial investment

Humpback whale migration is celebrated in Australia and is of great economic and culture value to many. Over the years, the Australian Government has been a leader to global conservation efforts in the recovery of whales and a leading voice for conservation at IWC. However, with growing cumulative threats along whale migration corridors and in critical habitats, we highlight urgency to safeguard populations in the region.

WWF encourages the Australian Government to:

- significantly increase its investment in actions to integrate the ecological role of whales in national climate adaptation and biodiversity policies;
- implement seasonal dynamic ocean management measures in migratory corridors and breeding grounds in coastal waters, and;
- Help implement marine protected areas in the Southern Ocean at CCAMLR, to safeguard important foraging areas for whales in the East Antarctica region.

WESTERN INDIAN OCEAN

High-density ship traffic, primarily consisting of container vessels, transits between Asia and Europe via the Red Sea and via southern South Africa. These ships pass through critical ocean habitats increasing the risk of ship strikes and underwater noise pollution.

ARABIAN SEA, COAST OF OMAN

This region is key foraging and breeding habitat of the Endangered Arabian Sea humpback whale that overlaps with high density of artisanal fishing using gillnets and ship traffic. Climate change is causing a weakening of northwest monsoon reducing productivity of fish resources in the region.

SOMALIA AND YEMEN

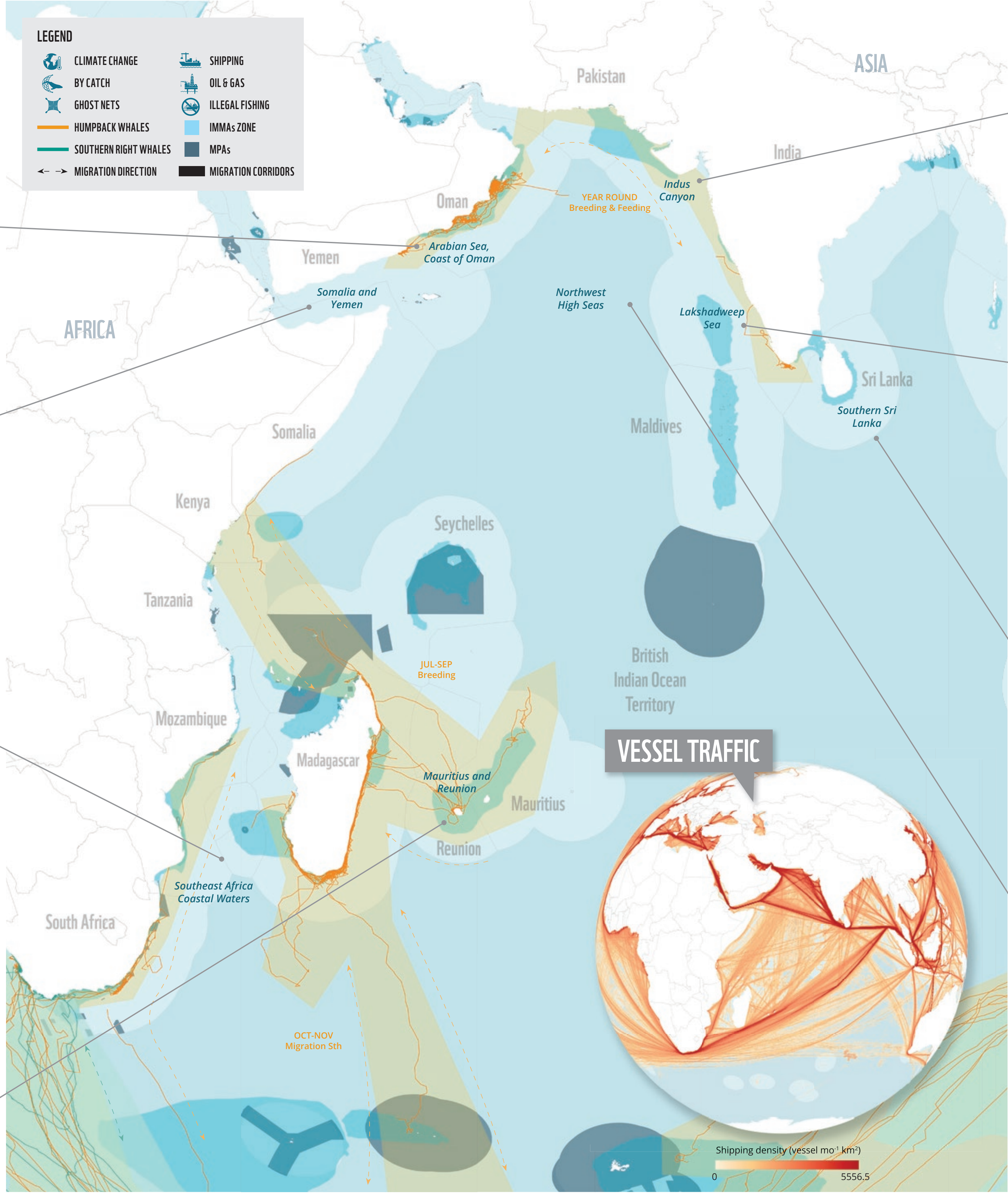
Historical whaling shows this area was important for northern Indian Ocean blue whales, Bryde's whales and sperm whales.

SOUTHEAST AFRICA COASTAL WATERS

Breeding grounds for southern right and humpback whales. Sea surface temperature changes impact the prey of southern right whales. Recovering whale populations overlap with high-density shipping traffic passing between Atlantic and Indian Oceans.

MAURITIUS AND REUNION

Breeding grounds for humpback whales and sperm whales found year round in the region that overlaps with growing shipping traffic transiting to and from Asia.



INDUS CANYON

Foraging habitat of Arabian sea humpback whales and blue whales. This is a productive area for fishing fleets from Gujerat (India) and Sindh province (Pakistan). High-density shipping traffic utilizes the ports in the Gulf of Kutch. There is intensive oil and gas production off Mumbai.

LAKSHADWEEP SEA

Breeding and transitory habitat of Arabian sea humpback whales is subject to the highest density artisanal fishing fleets in the northern Indian Ocean. There is high-density commercial shipping traffic through the Lakshadweep Archipelago.

SOUTHERN SRI LANKA

Important foraging ground for blue whales and other cetaceans. There is a high density of cargo ship and small vessel traffic from artisanal fishing and tourism boats in the area.

NORTHWEST INDIAN OCEAN HIGH SEAS

Large whale species transit areas on the high seas. There is Illegal use of oversized nets called driftnets (>2.5km driftnets). Fishing aggregation devices (FADs) and purse seine nets are used by distant water fleets fishing for tuna.

INDIAN OCEAN

The Indian Ocean hosts a wealth of marine life, including whale and dolphin species, with their ecology influenced by the high-latitude rich waters of the Southern Ocean to the south and a land-locked sea in the north, where seasonal monsoons drive localized areas of upwelling and ocean productivity.

It is a crossroads of global shipping traffic, subject to intense artisanal fishing activity related to escalating population pressures and attractive fishing grounds for high-value species such as tuna by industrial and often illegal fishing fleets. However, it is one of the most data-poor oceans for understanding the ecology and distribution of whales and the influence on them due to these growing human impacts.

Humpback whales are the most well studied of large whale species and are found throughout the Indian Ocean. There are populations with breeding grounds in the southwest Indian Ocean, the central Indian Ocean and along the coast of Western Australia, which are linked by well-defined north–south migration routes to foraging grounds in the Southern Ocean.[244,245]

Sperm whales and blue whales range occurs across the Indian Ocean to the Southern Ocean. Southern right whales, pygmy right whales, sei whales, fin whales and Antarctic minke whales (*Balaenoptera bonaerensis*) are found between the southern Indian Ocean and Southern Ocean.[246–248]

Globally, blue whales are listed as Endangered by the IUCN Red List. Antarctic blue whales occur in the tropical and subtropical Indian Ocean in Austral winter and spring, and a smaller subspecies, referred to as pygmy blue whales, is present year-round in the Indian Ocean. Although pygmy blue whales in the Indian Ocean are classified into two subspecies, Baleanoptera musculus brevicauda in the south and Baleanoptera musculus indica in the north, there is growing evidence there may be five populations within the Indian Ocean as identified by their unique vocalisations.[249,250] The population in the north are considered to be under threat due to slow life history and restricted range of critical foraging habitat overlapping with areas of high industrial activity including shipping, fishing and whale-watching.[251,252]

In the warm temperate and tropical areas of the Indian Ocean, other baleen whales, known as tropical whales, are found including Bryde's and Omura's.[253,434,435] The larger form of Bryde's whale (*B. brydei*) is associated with offshore areas, whereas the smaller form of this species complex (*B. edeni*) is associated with coastal waters.[255] As a species only formally described in 2003, the distribution of Omura's whales is less well understood, although evidence suggests they occur in both deep water and inshore areas.[434]

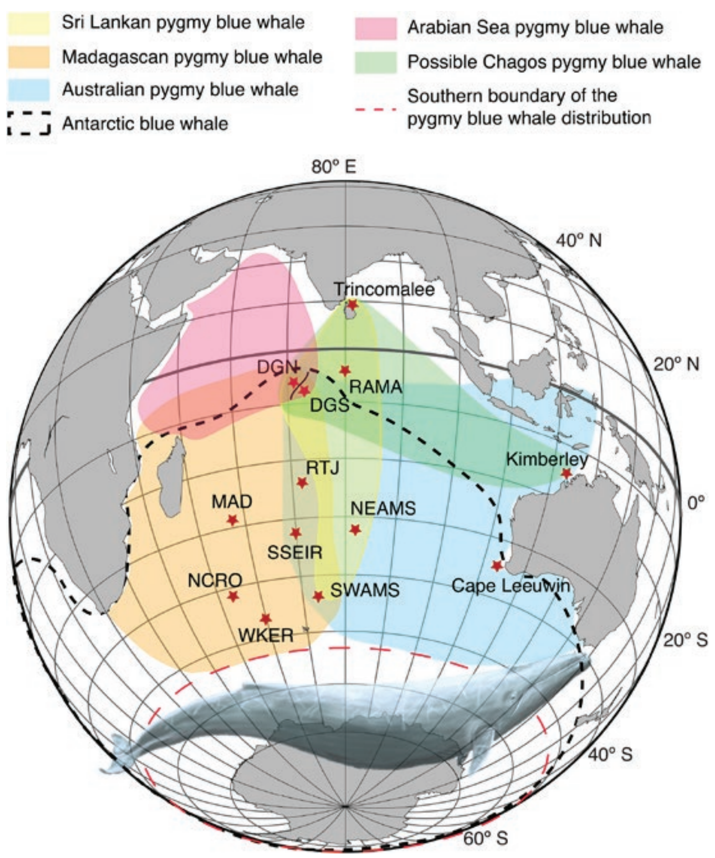


Figure 20: Distribution of five blue whale subpopulations throughout the Indian Ocean identified by their unique vocalisations recorded using special long-term underwater recorders.[250]

WESTERN INDIAN OCEAN

Endangered Arabian Sea humpback whales range from the Indus Canyon to the north, the Laccadive Sea in the southeast and Gulf of Aden to the southwest.[256,257] Seasonal upwelling of cold, nutrient-rich waters provides food for the whales that also mate, calve and nurse their young in the Arabian Sea.

The population has been genetically isolated for an estimated 70,000 years and recent photo-identification and satellite-tracking work has revealed east–west migration across low latitudes of the Indian Ocean between Oman and India.[258] This contrasts with the movements of other humpback whale populations, which typically migrate between tropical and polar or temperate waters.[259]

Illegal Soviet whaling during the 1960s killed 242 Arabian Sea humpback whales. This, along with other escalating human impacts, are the considered as the causes of its low population of less than 250 mature animals.[256,260] The population is at risk with scientists estimating that the population can handle no more than one mortality every two years as a result of growing human impacts.[261]

Humpbacks in the southwest Indian Ocean are referred to by the IWC as stock "C", comprised of four sub-stocks: C1 off the coast of the East African Mainland Coast from South Africa to Kenya, C2 in the Mozambique channel between Comoros Islands and Aldabra (Seychelles), C3 around Madagascar and C4 off the Mascarene Islands.[262] Whales wintering off the coast of Mozambique take a north–south migratory route along the east coast of South Africa and provide the evidence supporting the South East African Coastal Migration Corridor IMMA.[263]

As well as acting as a migratory corridor, the east coast of South Africa is a highly productive marine region with a seasonal event referred to as the "sardine run" in the austral winter. During this event, the smaller coastal form of Bryde's whale (*Balaenoptera edeni*) are found feeding on huge concentrations of sardines.[264,265]

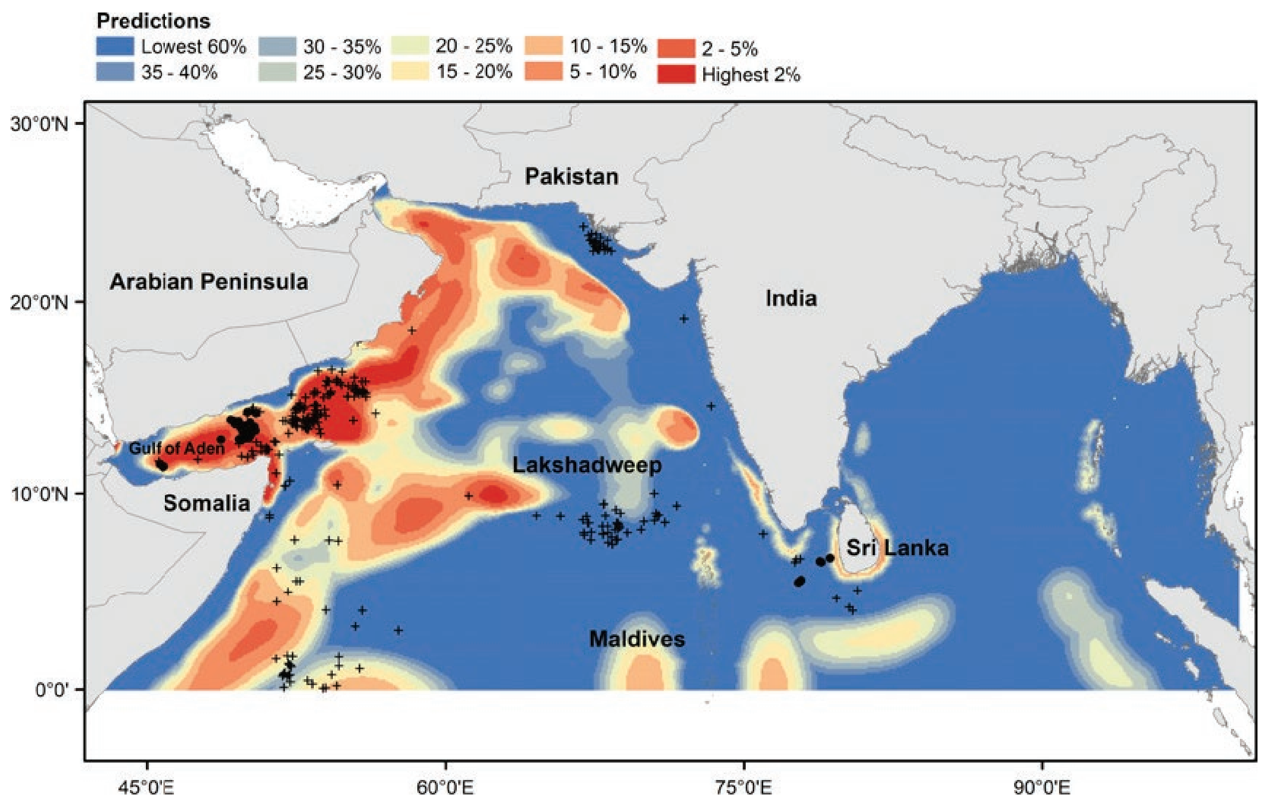
Satellite tagging of humpback whales off southern Madagascar, La Reunion and the Comoros islands reveals movements of humpback whales across the channel and around the coast of Madagascar within the breeding season followed by migrations to foraging grounds in the Southern Ocean for the austral winter.[266–268] However, scientists are still uncovering the migration patterns in this region. For instance, a single whale tagged off northeast Madagascar continued northwest across to Somalia while humpback whale song originating from the southwest Indian Ocean has been detected off the coast of Oman.[244,266] These studies provide evidence of southern hemisphere animals ranging into the northern waters of the Indian Ocean.[266]

Apart from dedicated studies conducted off Sri Lanka, the broader ecology of blue whales in the Indian Ocean remains poorly understood. However, data from Soviet whaling activities in the 1960s and more recent ecological studies indicate spatial overlap with localized high-density shipping traffic in the Gulf of Aden, Indus Canyon and off the southern coast of Sri Lanka.[251,252,269–271]

With little data, species distribution models help predict important areas for whales. Models show that critical habitats for pygmy blue whales are most likely to occur around the periphery of the Indian Ocean and also Island environments including Sri Lanka and Lakshadweep Archipelago.[252] Models also suggest that blue whale habitat shifts according to northeast and southwest monsoon seasons, although the Gulf of Aden remains suitable habitat in both seasons.

Off the coast of Sri Lanka, pygmy blue whales are associated with two important habitats including Trincomalee in the northeast and Marissa to the south. Photo-identification records indicate that a proportion of this population is resident year-round.[192,272–275] A blue whale birth has been witnessed off Trincomalee and mother–calf pairs have been observed in both areas.[276,277] The southern area is well known for aggregations that locate there for foraging during the northeast monsoon (December to March).[274] Localized studies conducted offshore from the coast of Marissa have estimated the presence of 270 blue whales, although it is understood more work is required across a broader geographic area to provide a more informed estimate on the size of this population.[270]

NORTHEAST MONSOON



SOUTHWEST MONSOON

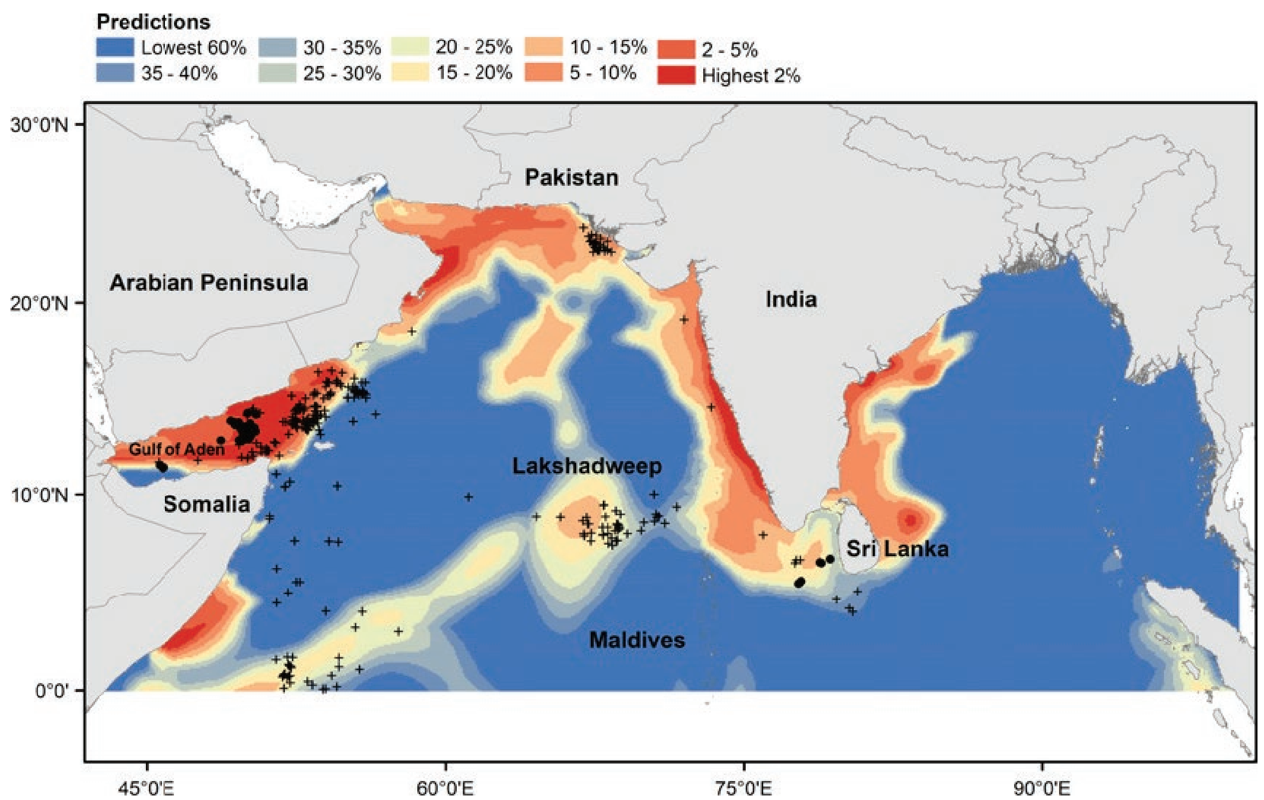


Figure 21: Models produced by scientists help predict important blue whale areas in the Indian Ocean based on environmental factors.[252]

CONSERVATION CHALLENGES

Threats to whales are linked to increased efforts of coastal and industrial fisheries and the increasing volume of shipping traffic. There are areas of traffic-density hotspots, some of which overlap with important habitats for large whales.

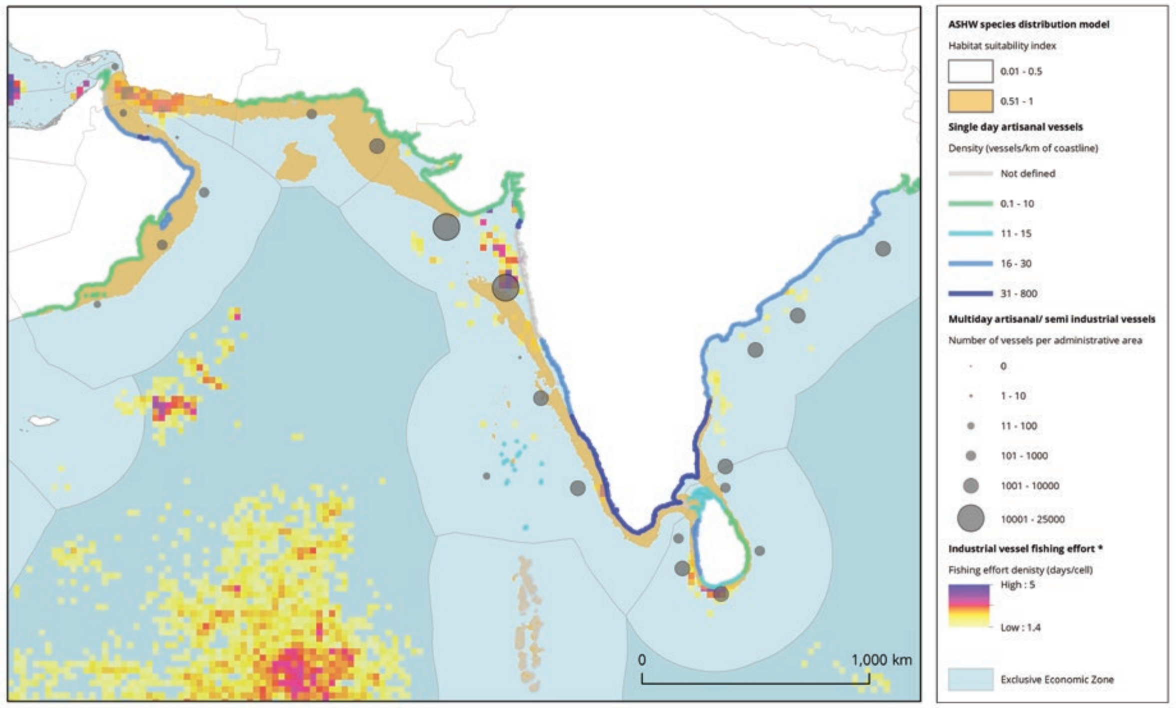
Fishing and entanglement in fishing gear

Fishing fleets, particularly those using drift or fixed gillnets (one of the gears most often associated with humpback whale entanglements elsewhere in the world),[278] are expanding throughout the central, western and northern Indian Ocean.[279] For example, pelagic gillnets (driftnets), some as long as 26km, now account for more than 34 per cent of all tuna landings in the region, and although observer coverage for fisheries in the Arabian Sea is extremely limited, cetacean bycatch is likely to be significant.[280] Threats presented by semi-industrial and industrial fisheries offshore and in the high seas are also poorly understood, although evidence suggests that coastal and distant water fleets continue to engage in the use of illegal (more than 2.5km) pelagic gillnets, and illegal unreported and unregulated fishing, witnessing the growth of unregulated fisheries.[281–283]

An estimated 4.1 million small cetaceans are thought to have been captured in gillnet fisheries between 1950 and 2018.[280] A recent study found it peaked at almost 100,000 individuals per year during 2004-2006, but has declined by more than 15 per cent since then, despite an increase in tuna gillnet fishing effort. Because bycatch estimates take little or no account of cetaceans caught by gillnet but not landed, of delayed mortality or sub-lethal impacts on cetaceans (especially whales) that escape from gillnets, of mortality associated with ghost nets, of harpoon catches made from gillnetters, or of mortality from other tuna fisheries, there is great concern the total cetacean mortality from Indian Ocean tuna fisheries may therefore be substantially higher than estimated. Declining cetacean bycatch rates suggest that such levels of mortality are not sustainable.[280]

Off the coast of Oman, more than 60 per cent of the humpback whales photo-identified have wounds and scars consistent with entanglement in fishing nets and lines. At least 11 individuals have been disentangled by rescue teams and fishers in Omani coastal waters over the last 20 years.

A study by Global Fishing Watch and Trigg Matt Tracking (2020) evaluated shipping data and satellite imagery to confirm vessel types and distribution in the northwest Indian Ocean.[281] It identified a large-scale illegal, unreported and unregulated fishing pelagic gillnet fishery representing 202 fishing vessels and 146 net markers occurring in the high seas, waters of Somalia, Yemen and a smaller extent of the Oman EEZ. Many of the vessels originate from regional states including Iran and to a lesser extent from Pakistan, Sri Lanka and India.[281] Vessel activity in Yemen and Somali EEZ has been shown to peak between February and May and September to October. Further assessment of satellite imagery revealed that 60–75 per cent of fishing vessels in these areas were not transmitting Automatic Identification System (AIS) signals, indicating that illegal, unreported and unregulated fishing can easily be underestimated and that multiple surveillance methods need to be introduced to track fisheries and inform management measures.



* Global Fishing Watch data. Extracted from 2016 fishing effort data (100th degree) and reaggregated to 0.25 degrees.

Figure 22: Arabian Sea humpback whale distribution overlayed with fishing data of artisanal from national fisheries statistics vessel registration records (2018) and industrial fishing effort from Global Fishing Watch AIS data.

Off the coast of Oman, more than 60 per cent of the humpback whales photo-identified have wounds and scars consistent with entanglement in fishing nets and lines.

Figure 23: Individual Arabian Sea humpback whales with severe mutilations caused by fisheries entanglement: OM11-010 (top left and top right) and OM03-004 (bottom left and bottom right). However, a congenital deformity in the latter cannot be excluded.[261] Photos Courtesy of Environment Society of Oman (top) and Alex Celini (bottom).

Shipping, including ship strikes and disturbance from vessel noise

The Indian Ocean includes some of the world's busiest shipping lanes, and new fast-ferry links are being planned and established throughout the region.

Port construction and expansion is occurring in key humpback whale habitat off Oman, India and Pakistan. Other forms of coastal development represent increasing threats in a region where human populations are growing rapidly, and infrastructure is expanding on a scale seen in few other parts of the world.

Shipping traffic in the northern Indian Ocean is distributed around the periphery of the continental shelf, with midocean transits occurring between the Laccadive Sea, Sea of Oman and Gulf of Aden. While the impact of midocean transits on migrating whales is not well understood, major shipping lanes overlap with important habitats for a range of whales off the southern coasts of Sri Lanka, India, Oman and Pakistan. The vessel traffic is dominated by cargo ships, with this sector subject to a 5 per cent annual increase between 2008 and 2018 based on container traffic volume.[284]

Oil and gas exploration and production

These activities carry threats of disturbance from seismic surveys and from construction and drilling noise, associated vessel traffic, and the potential for oil leaks and spills. Revenue from hydrocarbons continues to fuel development, human population growth and expansion of both into formerly remote parts of the region.[285]

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Climate change

Southern right whales breed off the southern coastline of Africa and feed in the Southern Ocean. This population was severely impacted from commercial whaling during the 20th century, with the population as low as 60 reproductive females at the termination of right whaling in 1935.[286] Key breeding areas are now found between Port Elizabeth and Cape Town, South Africa.

Annual census surveys are revealing high variability in counts of cow–calve pairs along the coast of South Africa with fluctuations of between 55 (2016), 536 (2018) and 92 (2018). The fluctuations are thought to be related to the influence of climate change on their prey and the population's preference for water less than 20˚C.[286,287] Additionally, data continues to show a decreased calving success, with females giving birth to a calf every four to five years instead of every three years.[286]

Poorly regulated whale-watching

Whale-watching is a US$2billion dollar industry worldwide and there is opportunity to grow the industry throughout the Indian Ocean region. At a workshop of the Indian Ocean Rim Association in 2016 discussing sustainable whale and dolphin watching tourism, common challenges identified included the lack of capacity and resources particularly for compliance and enforcement of activities in sensitive habitats.[288] Experts identified the need for improved access to information on sustainable whale-watching, species biology and best-practice approaches. In response, the IWC has released an online whale-watching handbook to support regulators and operators.[289]

For example, the whale-watching industry located on the southern tip of Sri Lanka began to grow in 2009. The increase in tourism in recent years has supported a growing whale-watching industry in Mirissa, which has also raised issues of whale harassment.[290] As a result, there is concern that high vessel traffic in cetaceans' feeding grounds is potentially altering their behaviour.[291] Previous studies in Mirissa have shown that blue whales have been observed in shipping lanes more often in recent years. Studies show that vessel noise from whale-watching can negatively impact whales and that regulations are needed to mitigate the impact of whale-watching through improved noise emission standards.[292]

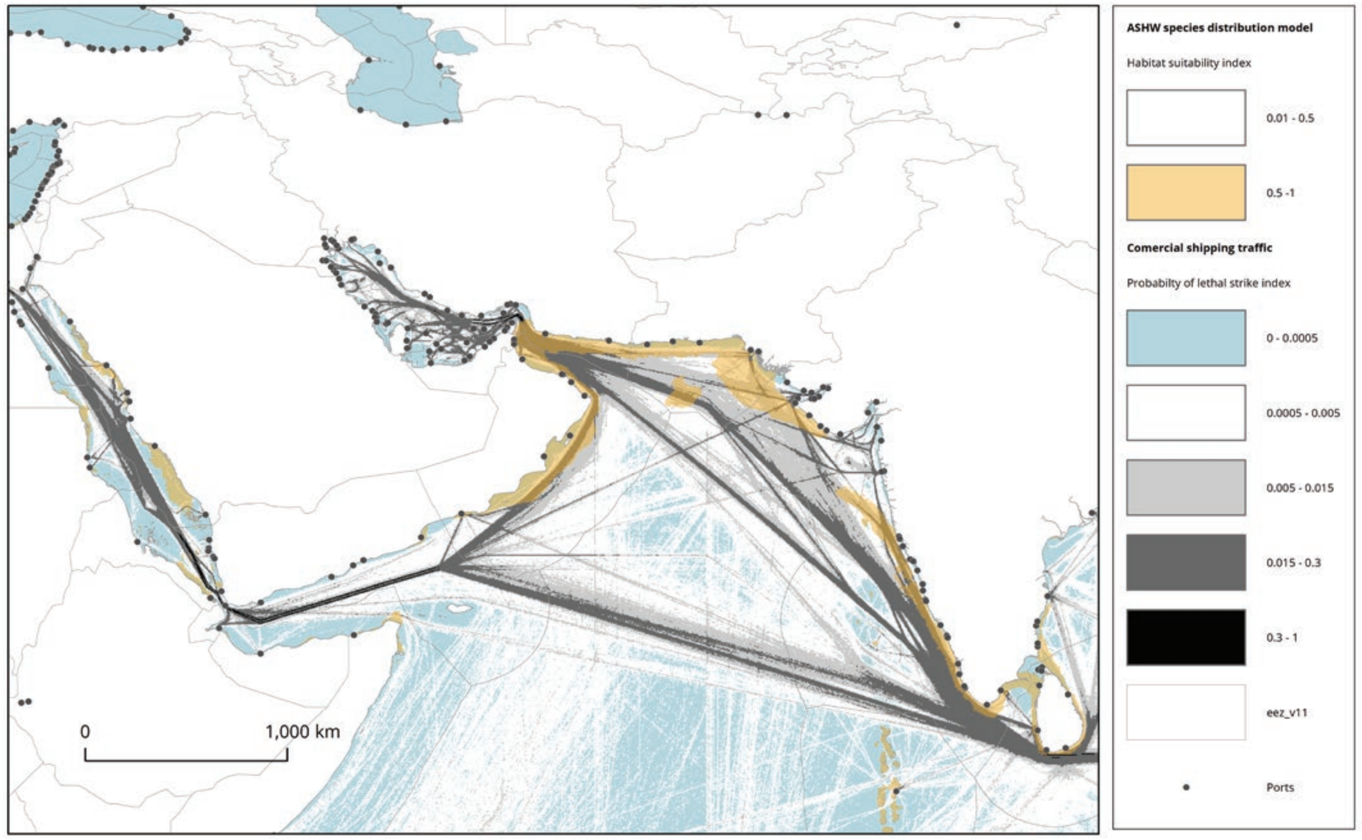


Figure 24: Ship strike risk assessment framework for Arabian Sea humpback whales in the north Indian Ocean.

CONSERVATION OPPORTUNITIES AND SOLUTIONS

Options to separate shipping from whales

The complex east–west exchange of whales within the western Indian Ocean as well as along their north–south migratory routes, particularly from southern Madagascar and the Mascarene Islands, puts whales into close association with high-density shipping routes.

Solutions to address growing overlap between ship traffic and important whale habitat are emerging. For Arabian Sea humpbacks, the highest risk areas exist along the Arabian Sea coast of Oman, where high-density shipping lanes containing fast-moving traffic intersect with areas of high habitat suitability (Figure 24 above).

Simulations indicate for vessels travelling at a speed over 14 knots, shifting of shipping traffic 40 nautical miles further offshore along the Arabian Sea coast could reduce strike risk by 80 per cent.

Initial steps have already been made in the Gulf of Masirah, Oman, where the Port of Duqm has implemented a whale management and mitigation plan that targets vessels transiting core Arabian Sea humpback whale habitat to slow down when transiting in and out of the port.[271]

The transoceanic passage of a whale between Oman and India and its subsequent passage along the west coast of India provided supporting evidence that resulted in the government of India listing humpback whales on the national Endangered Species Recovery List and engaging with state governments to address conservation action.[293]

Shifting shipping lanes in southern Sri Lanka

One of the highest densities of commercial shipping traffic worldwide occurs off the southern coast of Sri Lanka along the continental shelf, a hotspot for a range of whale and dolphin species.[274] Simulations have shown that moving shipping lanes 15nm to the south could reduce the strike risk to blue whales by as much as 95 per cent.[270] This action would also remove the risk of vessel strike with the local whale-watching industry and redirect ships through waters with 33 per cent less artisanal fishing vessels. Both government and industry have been engaged to investigate the possibility of moving shipping lanes, which is a process the Sri Lankan government must propose through the IMO. However, there is concern that by moving shipping lanes further offshore, business could be lost from service vessels and ports supplying services to commercial shipping traffic.[163]

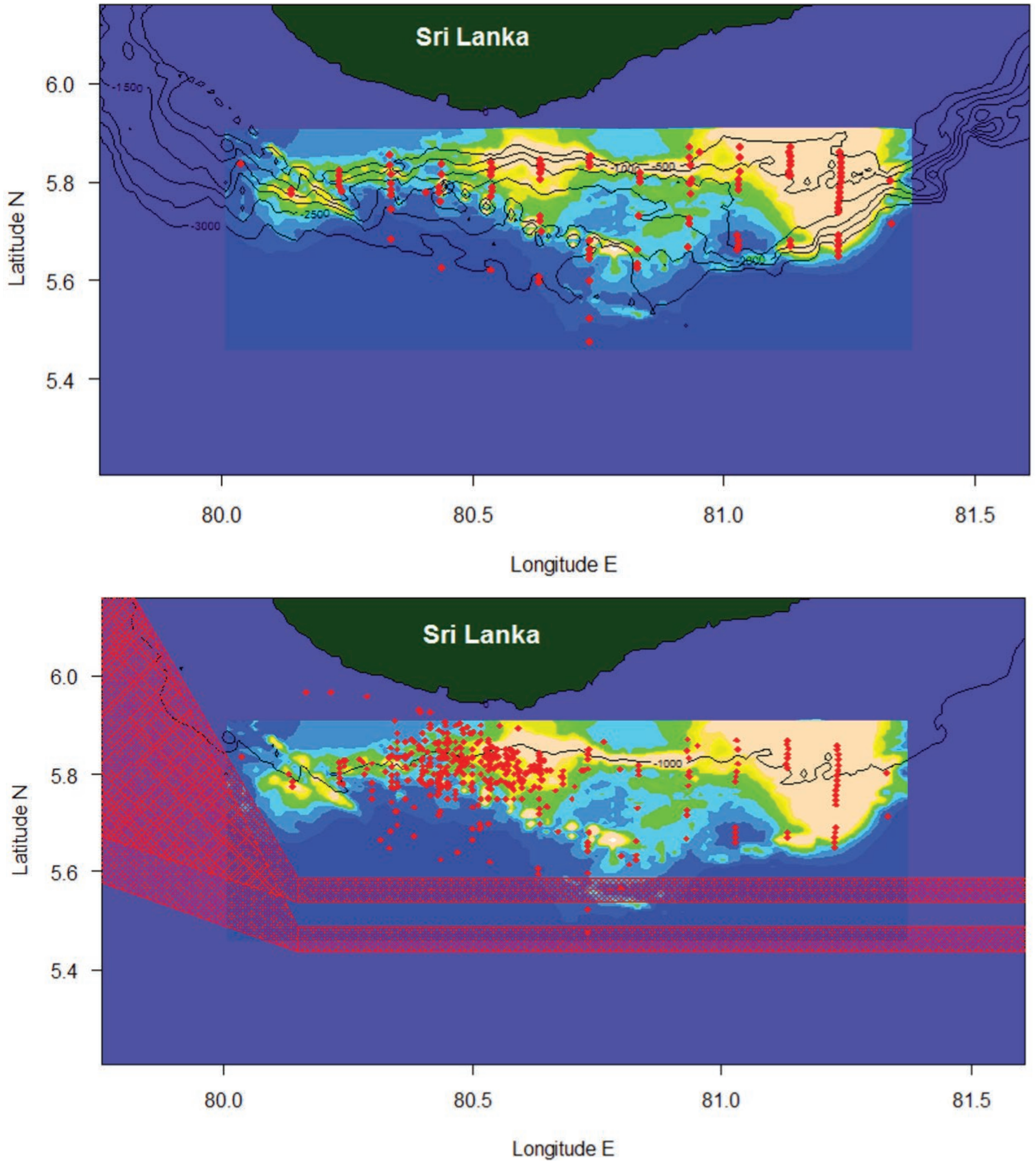


Figure 25: Above, shipping density off the coast of southern Sri Lanka derived from satellite AIS data. Black circles show crew transfer vessels operating out of Galle. Scale is shipping density in km per year.

Below, expected areas of high density shipping (red shading) if a Traffic Separation Scheme were established 15nm to the south of the current scheme. Traffic is more dispersed to the west between shipping coming from the Red Sea and west coast of Sri Lanka. To the east, almost all shipping is heading for Strait of Malacca. Coloured shading shows predicted whale density. Depth contour is 1,000m. Red circles indicate blue whale sightings from survey transects and sightings.[270]

Reducing fisheries bycatch through improved data and management by RFMOs

An RFMO – a regional fisheries management organization – is an international body made up of countries that share a practical and/or financial interest in managing and conserving fish stocks in a particular region. These include coastal states, whose waters are home to at least part of an identified fish stock, and "distant water fishing nations", whose fleets travel to areas where a fish stock is found.

WWF is active at the Indian Ocean's largest RFMO, the Indian Ocean Tuna Commission (IOTC), to improve fisheries practices and conservation and management of endangered, threatened and protected species that may be impacted by tuna fishing.

According to IOTC, the status of cetaceans is affected by a wide range of factors, including but not limited to direct harvest and habitat degradation, with the major concern for mortality as the capture in tuna drift gillnet fisheries.[280]

A key area where improvements for data collection and reporting are urgently needed lies with artisanal and small-scale fisheries. These vessels make up approximately 50 per cent of all IOTC tuna catches but currently have no reporting requirements. As a result, their activities remain unmonitored and the scale of the fleet's activities puts Indian Ocean marine ecosystems and tuna stocks in jeopardy.[294]

The IOTC Working Party on Ecosystems and Bycatch (WPEB) has developed a programme of work and identified priority actions[295] noting;

- the number of fisheries interactions involving cetaceans is highly uncertain and should be addressed as a matter of priority to determine the accurate status of cetacean species in the Indian Ocean;
- considering the high risk to cetaceans in the Indian Ocean from tuna drift gillnets, mitigation efforts/trials and pilots may be scaled, and results shared with WPEB;
- the current data on interactions and mortality of cetaceans is highly underestimated; if the fishing effort continues to increase it will likely have a negative impact, which needs to be dealt with through cooperation of member states; and
- appropriate mechanisms should be developed by the Compliance Committee to ensure member states are complying with their data collection and reporting requirements.

In addition, WWF is working with partners to implement measures to ban the use of large-scale driftnets (more than 2.5km in length) and to regulate fisheries by improving data acquisition, ultimately to reduce impact on ecosystems and marine species. A recent study engaged a network of trained skippers from the tuna drift gillnet fishery in the Arabian Sea to report target and non-target catch. This data was collected from 2013 to 2017 off the coast of Pakistan, where two fishing methods using multifilament gillnets were used; surface deployments and subsurface (i.e. headline of net set below 2m depth).[296] Predicted catch rates for targeted species did not differ significantly between the two fishing practices, although a drop in tuna (6.2%) and tuna-like species (10.9%) was recorded in subsurface sets. The probability of cetacean bycatch, however, was 78.5% lower in subsurface than in surface sets.[296]

To protect blue corridors for cetaceans from negative impacts of fishing, WWF urges the IOTC and other RFMOs to:

- prioritise bycatch mitigation efforts on all gear types including increasing observer coverage that includes Remote Electronic Monitoring;
- undertake ecological risk assessments to include endangered, threatened and protected (ETP) species such as cetaceans;
- adopt innovations such as subsurface gear settings as a means to reduce bycatch mortality in gillnets; and
- improve management of distance water fisheries operating in high densities.

© Alexis Rosenfeld

Identifying and protecting the most critical habitats for whales

The Indus River Canyon MPA was declared in 2018 and is the largest MPA in the Arabian Sea. It covers an area of 27,607km² and is a deep fissure located about 150km southeast of Karachi in the EEZ of Pakistan and southwest off the mouth of the Indus River. The canyon has unique physical features, with sloping margins about 1,800m deep, entering the Arabian Sea Basin.[297] The Convention on Biological Diversity, to which Pakistan is a signatory, requires nations under Article 2 to designate, regulate and manage geographically defined areas (protected areas) to achieve specific conservation objectives. A collaborative project between fishers and fisheries scientists at WWF-Pakistan has provided evidence of whale presence off the Indus Canyon, including humpback whales, blue whales, Bryde's whales and sperm whales.

In 2019, 37 IMMAs were identified in the western Indian Ocean and Arabian Sea by IUCN experts. National governments have the opportunity to implement a network of new MPAs based on this updated information.[298]

MEDITERRANEAN SEA

The Mediterranean is a sea is under pressure from a range of human activities.

EASTERN MEDITERRANEAN – HELLENIC TRENCH

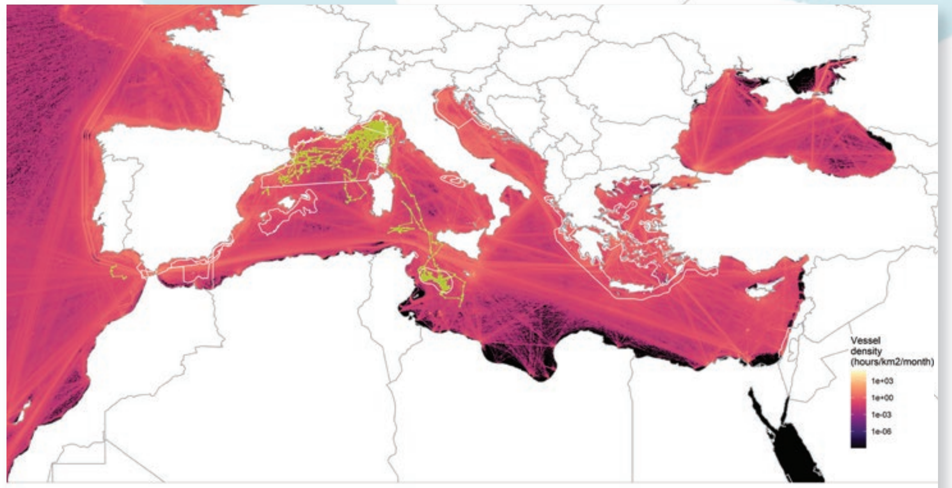
The Hellenic Trench is a core feeding, breeding and migrating habitat to several marine species, including the endangered Mediterranean sperm whales, Cuvier's beak whales, Mediterranean monk seals, dolphins and sea turtles, making it a biodiversity hotspot. In the eastern Mediterranean, whales are threatened by ship strikes – up to 50 per cent of stranded sperm whales have propeller or ship scarring. The area is also home to Cuvier's beaked whales that have suffered repeated dramatic mass strandings due to naval sonar exercises.

There are only 2500 sperm whales resident to the Mediterranean, with 200-250 animals living in the eastern region.

NORTHWEST MEDITERRANEAN

The northwest Mediterranean hosts an exceptional diversity and abundance of marine species primarily due to the high levels of ocean productivity. Fin whales, the second largest whale, follow seasonal oceanographic patterns. Sperm and beaked whales are found through deep water submarine canyons.

In 1999, the Pelagos Sanctuary for the Conservation of Marine Mammals was created and extended beyond the coastal zones of France, Monaco and Italy – the first cross-border area of the Mediterranean Sea dedicated to the protection of marine mammals – although high-density ship traffic and noise pollution impact populations.



High density ship traffic and underwater noise pollution is impacting cetaceans throughout the region.

MEDITERRANEAN SEA

The Mediterranean Sea is a unique ecosystem, one of the most dynamic and sensitive in the world. Yet it is one of the most endangered. Rich and diverse whale and dolphin populations use this semi-enclosed habitat.

Eight cetaceans species are resident to the Mediterranean Sea: fin, sperm, long-finned pilot (*Globicephala melas*) and Cuvier's beaked whales (*Ziphius cavirostris*), along with short-beaked common dolphins (*Delphinus delphis*); Risso's (*Grampus griseus*), striped (*Stenella coeruleoalba*), bottlenose dolphins (*Tursiops truncatus*). Six of them are listed as Threatened on the IUCN Red List of Threatened Species.

Sperm and fin whales are migratory and prevalent throughout Mediterranean Sea,[299] but exhibit distinctly different social structures and movement to populations elsewhere.[300,301]

NORTHWEST MEDITERRANEAN

The northwest Mediterranean hosts an exceptional diversity and abundance of marine species primarily due to the high levels of biological productivity generated by the oceanographic and geomorphological features of the basin.

Fin whales follow seasonal oceanographic patterns with a more restrictive distribution during spring and summer, where foraging conditions are most favourable in the northwest Mediterranean. During winter and autumn months, they appear to be more dispersive when the optimal foraging conditions diverge at a larger scale in the southern basin.[300,302,303]

However, potential migration patterns have not been adequately studied, since year-round research is needed to assess the migration patterns through continuous sampling methods, such as satellite tagging and visual surveys.[302,304]

Sperm whales exhibit seasonal distributional variations, and their occurrence is determined by their feeding, breeding and socialising needs. They use echolocation, regular and highly directional "clicks", to navigate and forage at depths up to 2,000m for up to an hour on average of 72 per cent of their day,[305] searching for squid found in deep submarine canyons as well as a variety of fish species.[306] Females spend their entire life as part of their family unit defending themselves against predators and caring for each other's calves.[307–310] In the Mediterranean, females occupy a constrained habitat year-round, while males disperse widely to exploit alternative feeding opportunities.[311]


© WWF-France

EASTERN MEDITERRANEAN - HELLENIC TRENCH

The Hellenic Trench is a core feeding, breeding and migrating habitat for several marine species, including the endangered Mediterranean sperm whales, Cuvier's beaked whales, Mediterranean monk seals, dolphins and sea turtles, making it a biodiversity hotspot in the eastern Mediterranean Sea.

These species are included in Annex II to the Protocol to the Barcelona Convention concerning Specially Protected Areas and Biological Diversity in the Mediterranean and in Annexes II and/or IV of the Habitats Directive 92/43/EEC. Parties to the Convention and Member States of the European Union are required to establish strict measures to guarantee their effective conservation.

The paramount ecological significance of the Hellenic Trench has been specifically recognized by international agreements, such as ACCOBAMS. However, to date only a small section of the area – mostly coastal – has become part of the Natura 2000 Network in which cetaceans not only have limited presence but are also inadequately protected.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CONSERVATION CHALLENGES

The Mediterranean Sea is subject to a range of human pressures, including maritime transport, natural resource extraction and renewable energy production, commercial and artisanal fishing and aquaculture, tourism, coastal development, and plastic pollution.[312]

High ship traffic

In relation to its small surface (0.8 per cent of the world's oceans) the Mediterranean Sea is one of the busiest seas in the world, hosting 20 per cent of seaborne trade, 10 per cent of world container throughput and over 200 million passengers. From the mid-1990s to the mid-2000s, the Mediterranean Sea recorded a rise in transit capacity of 58 per cent, combined with an increased size of vessels by 30 per cent since 1997. It is expected that shipping in the Mediterranean basin will increase in the coming years, both in number of routes and traffic intensity. Marine traffic in the Mediterranean Sea is expected to double in 15 to 20 years.[312]

While 30 per cent of the world's maritime traffic transits through the Mediterranean Sea, the northwest also experiences heavy traffic, especially in summer. Collision risks associated with this significant traffic are substantial, and it is growing due to an increase in the number, size and speed of ships. Impacts to individual animals are not always fatal, but even non-fatal interactions potentially result in suffering and reduced fitness. Between 8 and 40 fin whales are estimated to be killed by ship strikes in the western Mediterranean per year.[313]

In the Pelagos Sanctuary area, due to the high concentration of cetaceans and the heavy maritime traffic, the ship strikes rate is 3.25 times higher than elsewhere in the Mediterranean.[313] Collisions with cetaceans increase the risk of death or injury to both people and animals and can cause damage to vessels, including to hulls, propellers, shafts, rudders and key logging or sensing equipment such as sonar domes. Additionally, underwater noise – generated from a range of sources, including maritime traffic – is a growing threat to the health and well-being of marine mammals and other marine species.

Cetaceans in the Hellenic Trench are already facing a series of direct and severe threats, such as anthropogenic noise by seismic testing, naval exercises and ship traffic, and ship strikes.[314]

Oil and gas exploration

Between 2016 and 2019, the Greek government granted the oil and gas industry a large portion of the Hellenic Trench (Ionian and Cretan Seas), approximately 56,000km², for hydrocarbon exploration and exploitation. An additional area of 33,000km² in South Crete is considered to be granted and a Strategic Environmental Assessment has already been approved.[315]

While there is abundant scientific evidence demonstrating the detrimental impacts of hydrocarbon development on marine mammals throughout their whole cycle – especially to the most acoustically sensitive species such as Cuvier's beaked whales and sperm whales – precautionary measures to protect marine biodiversity from noise impacts are seriously lacking.[316] Moreover, under national legislation, seismic testing/geophysical surveys are not subjected to Environmental Impact Assessments or other appropriate assessments (as directed in article 6 (3) Habitats directive).[316]

These ongoing plans also neglect the two sets of guidelines, which are already adopted by almost all Mediterranean states, namely the ACCOBAMS Noise Guidelines endorsed most recently in November 2020 at the Meeting of the Parties 7 (MOP7),[317] and the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities adopted by more than 120 Parties at CMS COP12 in 2017.

In 2019, more than 100 scientists and marine mammal experts around the world signed a petition addressed to the Greek government asking for the immediate ban of any new oil and gas development in the region.[318]

Up to September 2021, no exploration or production activities have taken place in the area. As a result of the COVID-19 pandemic, plans have been further delayed or shelved with a shift in investment priorities by the oil industry and growing local opposition.

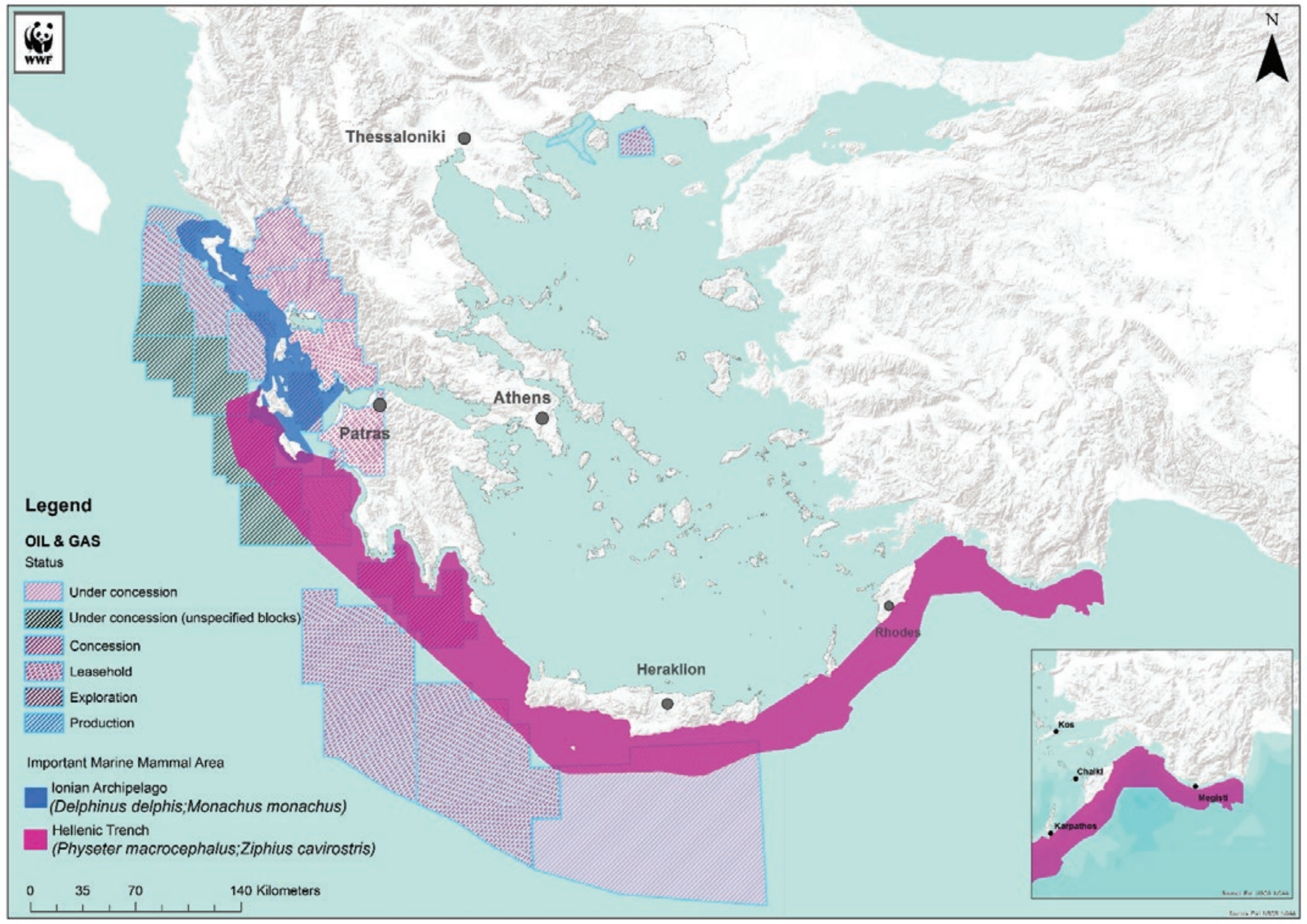


Figure 26: Oil and gas concessions and Important Marine Mammal Areas in Greece.

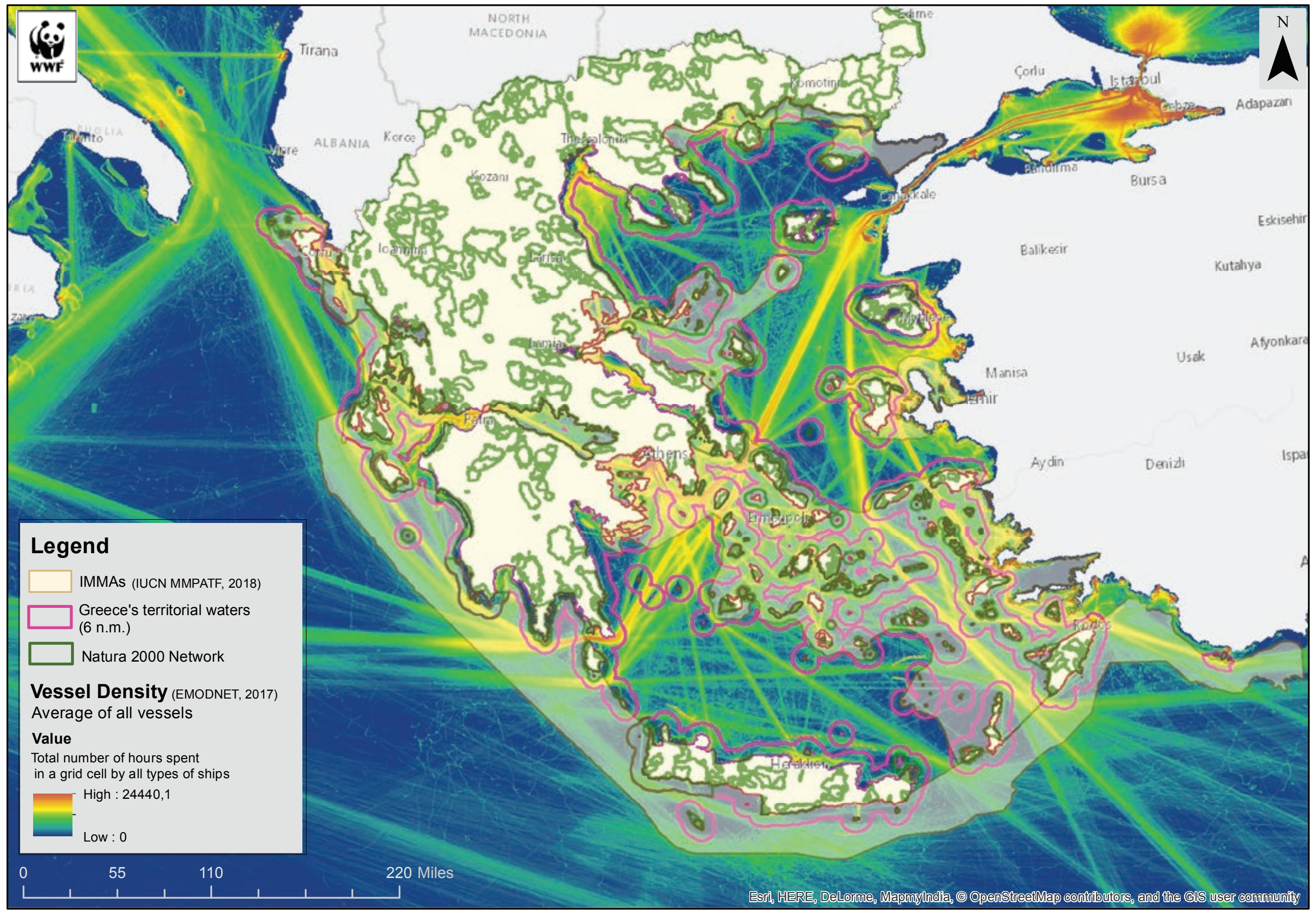


Figure 27: Ship traffic in Greece occurs within Important Marine Mammal Areas and Natura 2000 sites, critical habitat for endangered Mediterranean sperm whales.

Photo: This endangered Mediterranean sperm whale was a lucky survivor of deep propellor scars. © Chris Johnson

CONSERVATION OPPORTUNITIES AND SOLUTIONS

Protecting important ocean areas for whales in national and international waters

In 1999, the Pelagos Sanctuary for the Conservation of Marine Mammals was created and extended beyond the coastal zones of France, Monaco and Italy – the first cross-border area of the Mediterranean Sea dedicated to the protection of marine mammals. It is recognized as a Specially Protected Area of Mediterranean Importance under the Barcelona Convention. By expanding protective measures beyond national waters, the Pelagos Sanctuary set a precedent for the implementation of pelagic protected areas in the high seas contributing to conservation in two ways: locally, by protecting important cetacean foraging and breeding grounds in the Ligurian Sea and by providing “umbrella” protection to other marine predators in this area; and regionally, by empowering other conservation measures, such as the Specially Protected Areas Protocol of the Barcelona Convention and the wider goals of ACCOBAMS.[319]

However, in the Mediterranean, the surface covered by MPAs is so small there is concern that they are ineffective to wide-ranging whales and dolphins. Only 2.48 per cent of the Mediterranean Sea is currently covered by MPAs with a management plan, only 1.27% by MPAs that effectively implement their management plan, and only 0.03% by fully protected areas. Protection levels should be increased and more evenly distributed across political boundaries and ecoregions to deliver tangible benefits for biodiversity conservation.[320]

In response, in 2016, the IUCN Marine Mammal Protected Areas Task Force designated 26 IMMAs throughout the Mediterranean to protect the breeding and feeding grounds of sperm and fin whales and other marine mammals.[321] Spain recently created a new Marine Cetacean Migration Corridor, declared as a national MPA in June 2018 and as a Specially Protected Area of Mediterranean Importance under the Barcelona Convention in December 2019.[322]

Improving guidance and regulations for mariners

Marine traffic management, through speed reduction, areas to be avoided and/or Traffic Separation Schemes are identified as the best tools available to date to mitigate the impact of ship strikes, speed reduction being the most efficient.[323] Scientific research has identified a navigation speed threshold between 10 and 13 knots below which the risk and consequences of collisions decrease significantly.[324] Therefore, the need to establish a PSSA in the northwest Mediterranean was identified to mitigate in the best way possible shipping impacts on marine mammals in this area.

Based on recent recommendations by the IWC, ACCOBAMS and the IUCN, WWF is advocating with government representatives of France, Italy, Monaco and Spain for mitigation measures to reduce ship strikes in the area supporting the resident population of whales of the northwest Mediterranean, through the establishment of a PSSA designated by the IMO.

A key advantage of a PSSA designation is that it increases international awareness regarding the environmental sensitivity of the area and its vulnerability to damage from shipping activities and improves compliance with the measures taken to protect the area.

Several examples of PSSAs, including Papahānaumokuākea Marine National Monument PSSA (northwest Hawaiian Islands) and the Galápagos Archipelago PSSA or the Baltic Sea PSSA, show that the existence of a PSSA can have the immediate effect of altering perceptions of the area and result in changes in the behaviour of users.[325]

In Greece, more than 50 per cent of sperm whale strandings examined between 1992 and 2016 along the coast near the Hellenic Trench showed clear evidence of ship strikes, raising strong conservation concerns for this population. As a result of these ongoing efforts between WWF Greece, the Pelagos Cetacean Research Institute, the IFAW, and OceanCare, in early 2021, the Greek Ministry of Defence through the Hellenic Hydrographic Office, with the support and collaboration of the other ministries and the Greek shipping community, has issued two NAVTEX warnings. These instruct mariners transiting through the area to be cautious, to look out for marine mammals and to take action to minimize the risk of ship strikes.

CONSERVATION IN ACTION: STUDYING MEDITERRANEAN GIANTS

For more than 20 years, WWF has been conducting whale and dolphin conservation field projects in the Mediterranean, mainly focusing on fin whales, sperm whales and pilot whales. These field projects have contributed to an improved understanding of their population and distribution. The team has studied chemical pollutant loads accumulating in whales through the marine food web including from growing microplastic pollution. Additional conservation field science includes assessment of pregnancy rates, genetic structure and photo identification of individuals. WWF is now focusing on mitigating ship strike impacts on cetaceans through three strategies:

- Advocacy for a PSSA to be created with strong and effective associated measures for traffic management;
- Development of an anti-collision system based on real-time passive acoustic localization of cetaceans; and
- Field work to study fin whales’ behavioural response to shipping traffic and situation of collision.

© MAITE BALDI / WWF-France

Photo: The WWF-France Blue Panda conducts field research to better understand fin whale distribution and important foraging areas.

SOUTHWEST ATLANTIC OCEAN

The southwest Atlantic Ocean is a unique region with a large and diverse marine megafauna. In the past 30 years, human occupation of coastal areas and exploration of oceanic habitats has expanded dramatically in the region, bringing new threats to migratory whales.

BRAZIL

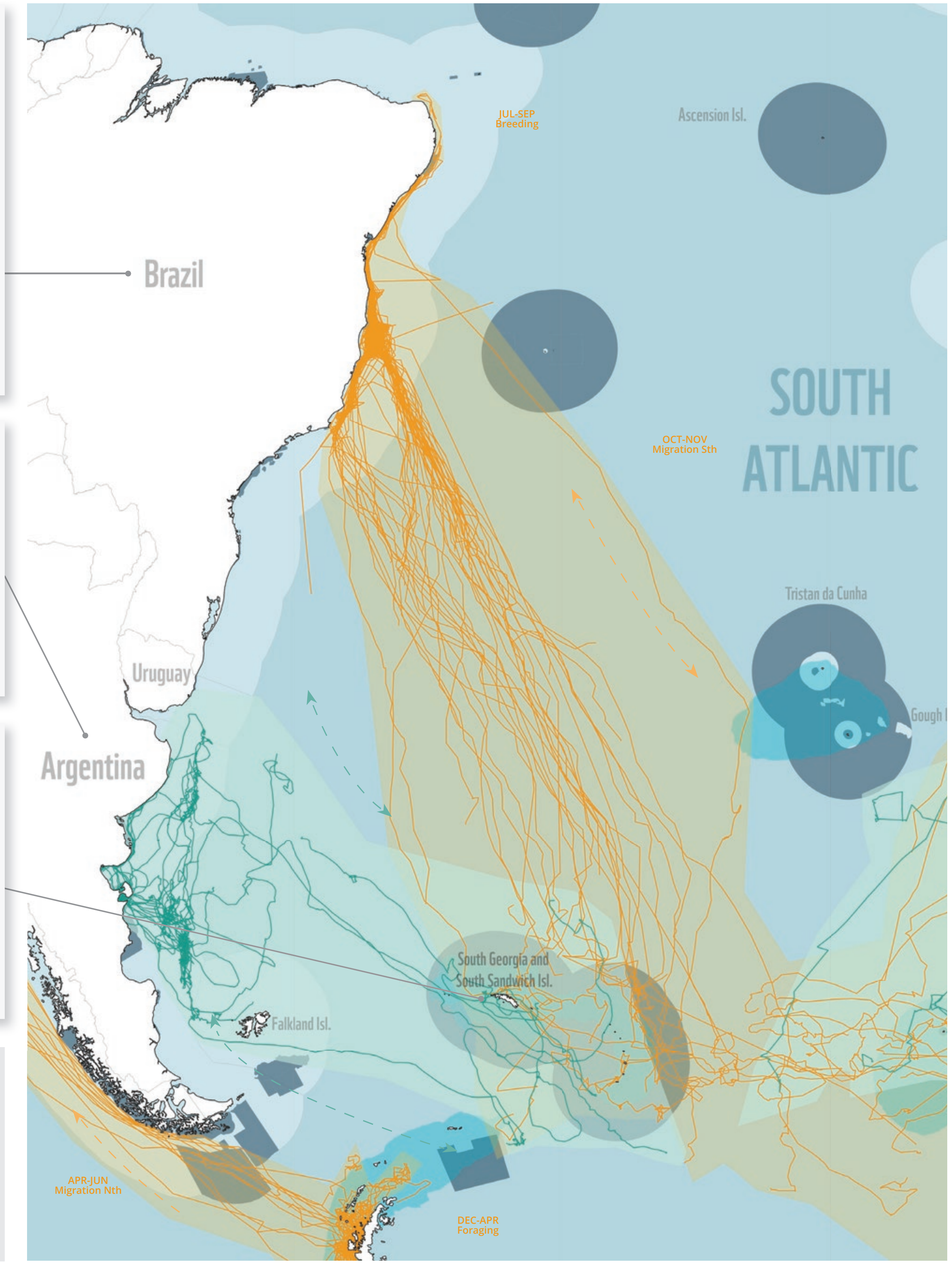
Humpback, sei and minke whales prefer warmer waters off the coast of Brazil, with humpbacks concentrating over the continental shelf to breed and minke and sei whales in more pelagic environments.

ARGENTINA

Southern right whales breed in nearshore waters off Argentina (near Peninsula Valdés) and occur in smaller numbers off Uruguay and southern Brazil.

SOUTH GEORGIA AND SOUTH SANDWICH ISLANDS

Migratory whales typically spend the winter and early spring in low- to mid-latitude breeding and calving grounds.



Satellite tag data – Appendix 1

The topography and oceanography of the southwest Atlantic Ocean favours the formation of highly productive ecosystems, including the sub-tropical convergence in middle latitudes and the Antarctic Convergence (or polar front) located in high latitudes at the edge of the Southern Ocean. Other important, rich environments include coastal areas close to the runoff or major river systems like the La Plata River, seamounts in the Atlantic basin and near the mid-Atlantic ridge, and areas around major oceanic Islands such as the Falkland, the South Georgia, and the South Sandwich Islands.

Many species of cetaceans are found in the southwest Atlantic Ocean. They include highly migratory baleen whales such as blue, fin, sei, Antarctic minke, dwarf minke (*Balaenoptera acutorostrata*), humpback and southern right whales, as well as endemic, coastal dolphins like the Franciscana (*Pontoporia blainvillei*), the Guiana dolphin (*Sotalia guianensis*) and the Lahile's dolphin (*Tursiops truncates gephyreus*). Migratory whales typically spend the winter and early spring in low- to mid-latitude breeding and calving grounds. Humpback whales, sei whales and the two minke whale species prefer warmer waters off the coast of Brazil, with humpbacks concentrating over the continental shelf and minke and sei whales in more pelagic environments. Right whales prefer nearshore waters off Argentina (near Peninsula Valdés)[326] and also occur in smaller numbers off Uruguay and southern Brazil. Blue and fin whales are rare in low latitudes of the southwest Atlantic. At the end of the spring, migratory whales move toward feeding habitats in highly productive areas of the southern South Atlantic, where their primary prey (zooplankton such as the Antarctic krill and copepods) is more abundant. Humpback whales migrate through a relatively narrow corridor from the central coast of South America toward sub-Antarctic waters near the Scotia Sea,[327,328] while right whales disperse across various habitats, including the outer continental shelf off Argentina and the Falkland Islands, the South Atlantic Basin and the Scotia Sea.[329] The migratory movements of blue, fin, sei and the two minke whale species are poorly known. Sei whales and dwarf minke prefer feeding grounds located in cold temperate and sub-Antarctic zones while Antarctic minke whales concentrate in foraging areas near the Antarctic pack ice.

CONSERVATION CHALLENGES

All species of whales were heavily hunted in the southwest Atlantic. Right, sperm and humpback whales were taken by pre-modern whaling (between the 17th and the 19th centuries)[330] and humpback, right, blue, fin, sei and sperm whales were heavily exploited by modern whaling in the 20th century.[331] Minke whale species were not as heavily impacted. The moratorium on commercial whaling implemented by the IWC ceased all whaling activities in the southwest Atlantic Ocean, but some species have not yet recovered to their pre-exploitation levels.[332]

In the past 30 years, human occupation of coastal areas and anthropogenic use of oceanic habitats has expanded dramatically, bringing new threats to migratory whales.[129] These threats include collisions with vessels and underwater noise related to increasing ship traffic associated with shipping activities, fisheries and offshore exploration and exploitation of fossil fuels and mining.[333–335] Entanglements in fishing gear have become a global problem to all cetaceans and are believed to be a growing threat for migratory whales, particularly for calves and juveniles, in the southwest Atlantic. Global warming is causing major changes in the primary feeding grounds of most whales, including significant shifts in prey distribution in the southern South Atlantic.[52] Climate variability is known to affect the reproductive rates of whales feeding near the Scotia Sea.[336,337] Other threats include chemical pollution and emerging diseases, especially around highly human-populated areas.

The impact of modern threats to migratory whales in the southwest Atlantic is poorly understood. Significant mortalities of humpback whales in Brazil and right whales in Argentina have been observed in recent years,[338,339] but their causes are not well known. Further research is needed to determine how threats affect each species, what their cumulative impacts are, and to assess seasons and areas of greater risk.

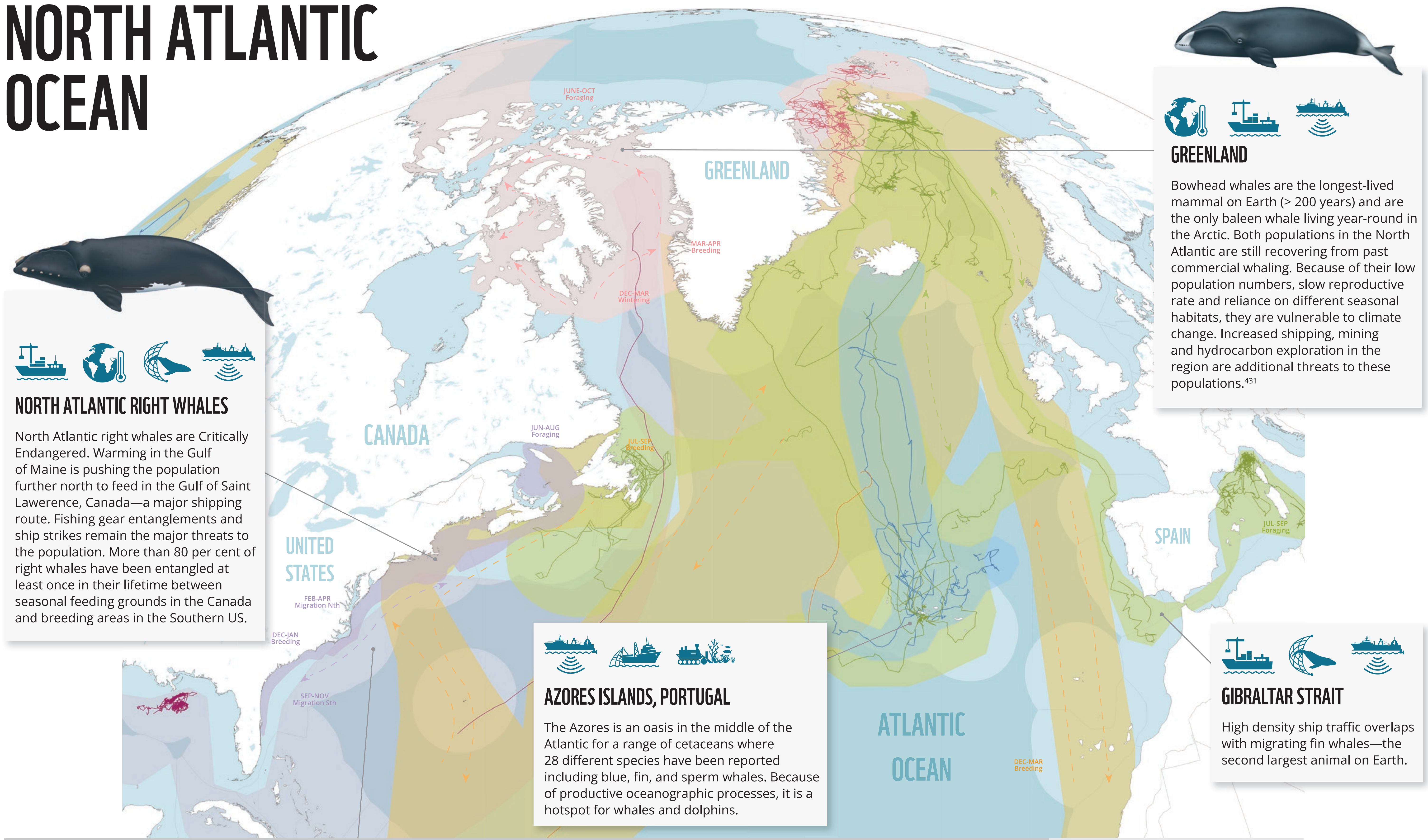
CONSERVATION OPPORTUNITIES AND SOLUTIONS

Improving conservation of whale migratory routes and migratory destinations can be achieved through collaboration of multiple stakeholders via national and international efforts. While the impact of existing threats is poorly characterized in the southwest Atlantic, many range states have regulations to protect whales and have implemented or are in the process of implementing national action plans to promote their conservation within their territorial waters.[340] Existing management actions include the establishment of protected areas, particularly in areas within national jurisdiction, but action is needed to further identify and reduce the effect of threats, especially in international waters.

At a regional level, the IWC has developed a Conservation Management Plan for southern right whales in the southwest Atlantic, where member countries have identified and been promoting research, conservation and management actions, including capacity building to minimize effects of some threats through facilitating multilateral collaborations. The IWC's Global Whale Entanglement Response Network[341] has been partnering with government authorities within the region's range states to establish local response teams to release entangled migratory whales from fishing gear and training workshops have been carried out in Argentina and Brazil. The immediate aim of the programme is to build safe and effective entanglement response capability around the world. The long-term goal is to prevent entanglements from happening in the first place.

Ongoing plans to establish a global southern right whale consortium should be encouraged as this can be an instrument to formalize and facilitate multinational collaboration to promote science and conservation efforts that require engagement of stakeholders at global and regional (ocean basin-wide) scales. For example, the IUCN's IMMAs initiative could help to define key whale migratory habitats in the southwest Atlantic.[263]

NORTH ATLANTIC OCEAN



GREENLAND

Bowhead whales are the longest-lived mammal on Earth (> 200 years) and are the only baleen whale living year-round in the Arctic. Both populations in the North Atlantic are still recovering from past commercial whaling. Because of their low population numbers, slow reproductive rate and reliance on different seasonal habitats, they are vulnerable to climate change. Increased shipping, mining and hydrocarbon exploration in the region are additional threats to these populations.[431]

NORTH ATLANTIC RIGHT WHALES

North Atlantic right whales are Critically Endangered. Warming in the Gulf of Maine is pushing the population further north to feed in the Gulf of Saint Lawerence, Canada—a major shipping route. Fishing gear entanglements and ship strikes remain the major threats to the population. More than 80 per cent of right whales have been entangled at least once in their lifetime between seasonal feeding grounds in the Canada and breeding areas in the Southern US.

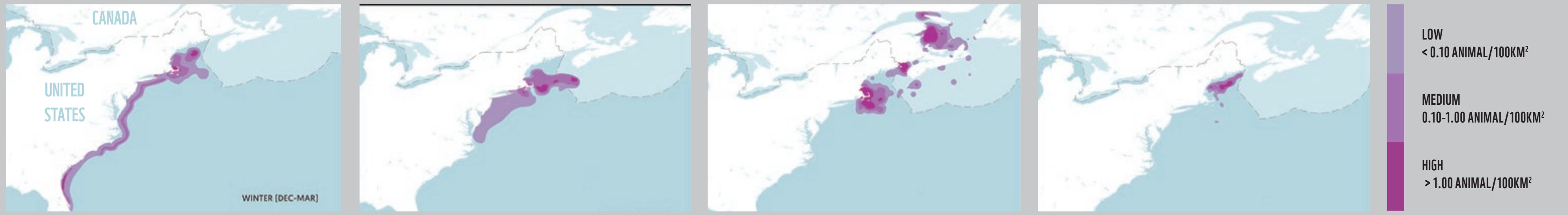
AZORES ISLANDS, PORTUGAL

The Azores is an oasis in the middle of the Atlantic for a range of cetaceans where 28 different species have been reported including blue, fin, and sperm whales. Because of productive oceanographic processes, it is a hotspot for whales and dolphins.

GIBRALTAR STRAIT

High density ship traffic overlaps with migrating fin whales—the second largest animal on Earth.

SEASONAL DISTRIBUTION OF NORTH ATLANTIC RIGHT WHALES



LEGEND

- CLIMATE CHANGE
- BY CATCH
- UNDERWATER NOISE
- BOWHEAD WHALES
- NORTH ATLANTIC RIGHT WHALES
- SPERM WHALES
- SHIPPING
- WHALING
- FIN WHALES
- BLUE WHALES
- HUMPBACK WHALES
- MIGRATION CORRIDORS

Whale illustrations © Uko Gorter

NORTH ATLANTIC OCEAN

© Brian J. Skerry / National Geographic Stock / WWF

CONSERVATION EMERGENCY: NORTH ATLANTIC RIGHT WHALES

In 2020, the IUCN listed North Atlantic right whales (*Eubalaena glacialis*) as Critically Endangered (previously listed as Endangered), highlighting the gravity of the extinction crisis facing this species.[342] Since 2017, 50 animals were recorded as dead or seriously injured and likely to die from their injuries.[343] In 2020, the population was at its lowest in nearly 20 years at 336 animals, a dropped of 8 percent from 2019.[344]

Prior to 2011, North Atlantic right whales were on a slow but steady recovery from centuries of whaling with an increase in abundance at about 2.8 per cent per annum from 270 individuals in 1990 to 483 in 2010.[345] But since, the species is on a downward trajectory and scientists now warn that they may go extinct in less than 30 years.[346,347] To recover, less than one right whale each year can die from human interaction across the species range in both Canada and the United States (US).[348]

CONSERVATION CHALLENGES

Fishing gear entanglements and ship strikes remain the major threats to the population, but warming oceans precipitated changes and exacerbated the problem. More than 80 per cent of photographed whales had been entangled at least once in their lifetime.[349] Sublethal chronic entanglement stress is affecting long-term health of the population with North Atlantic right whales' average body length shrinking by a metre or more since the early 1980s.[350] As wounded animals have less energy to devote for growth and reproduction, even calves nursing from entangled mothers are smaller.[350] Recent research reports North Atlantic right whales are in poor health compared to southern right whales due to these multiple stressors which is impacting their overall reproductive success and recovery.[351]

North Atlantic right whales' migration and feeding behaviour follow the distribution and abundance of their preferred food source – copepods of the genus Calanus and more specifically, Calanus finmarchicus.[352,353] These large whales need to feed on high-density patches of copepods to ensure their daily energetic demand; an average-sized adult (about 40 tons) must consume approximately 100 million copepodites each day.[354] In 2010, warming seas in the Gulf of Maine led to a sudden environmental shift causing decreases in the abundance of Calanus [355,356] pushing their distribution further north and causing a decline in calving rates.[357,358]

Historically, North Atlantic right whales were observed in five major feeding grounds from Cape Cod Bay and Massachusetts Bay during the spring, to the Great South Channel during the late spring and summer, migrating to the Bay of Fundy and Roseway Basin in Canada during the late summer and autumn.[356] Around 2015, scientists reported a shift of right whales northward with an increased presence in the Gulf of St. Lawrence, Canada – one of the busiest shipping lanes in the world.[359] Every year, from May to December, about 40 per cent of the population forages here.[360] However, climate change has caused uncertainty as the rest of the population is elsewhere, dispersed or in unfamiliar places with some areas protected and other areas without management. Recent findings suggest that prey abundance in the Gulf of St Lawrence may not be sufficient in most years to support successful reproduction of North Atlantic right whale.[361]

CONSERVATION OPPORTUNITIES AND SOLUTIONS

Mixed management of fishing and shipping

Over the past twenty years, large-scale management efforts were developed in both the United States and Canada, including moving shipping lanes away from critical habitats. These included shifts in traffic separation schemes (Bay of Fundy, 2003 and Boston, 2007), designation of voluntary Area to Be Avoided (ATBA) (Roseway Basin, 2007 and Great South Channel, 2009), and seasonal and dynamic slowdowns (U.S. 2008). However, recent findings showed that compliance or cooperation for US vessel slowdowns have generally been low, and these regulations fell short of adequately protecting the whales (e.g., vessel size limit, exemptions, and enforcement).[362] Through the Atlantic Large Whale Take Reduction Plan, the US has also pioneered and implemented several fishing requirements including seasonal closures and fishing gear modifications such as sinking groundlines and weak links for flotation and/or weighted devices (2007) whereas fishing measures for Canada have historically been largely insufficient.[363,364]

In 2017, 12 right whales died in Canadian waters, setting a record high of human-caused mortalities, and prompting the declaration of an Unusual Mortality Event in the United States and closures of lucrative fishing grounds and slowdowns of main shipping corridors in the Gulf of St Lawrence in Canada. In response, Canada quickly developed large-scale management measures including the use of dynamic and seasonal fishing closures and vessel slowdowns triggered by whale presence (both visually or acoustically detected) across the Gulf of St Lawrence and designated critical habitat.[365] These measures are now viewed as more stringent (any fixed-gear fishing ground in the Gulf of St Lawrence may be closed from a single acoustic or visual detection) and more adaptable to the dynamic reality of North Atlantic right whale shifting range due to climate change. However, both countries still have work to do, including adopting compliant dynamic management across the species range and new habitat, improving gear marking, promptly issuing new regulations to reduce vertical lines, and promoting existing and emergent whale safe technologies such as ropeless fishing gear.

Reducing vertical lines in the water to eliminate entanglement

Several new and emerging ropeless technologies – marking and retrieving traps without buoys or end lines – are currently being explored and tested in both Canada and the US.[366,367] The development and operational use of ropeless fishing has the promise to eliminate most fixed gear entanglements as well as allow access to closed fishing grounds.[368] Ropeless technologies represent a more fundamental change for fishers. There is further development and testing needed to ensure that these technologies provide a safe, legal, practical and affordable alternative to scale up its use and impact in a changing climate.[367]

Existing whale-safe technologies include weak ropes or weak breaking points (e.g. sleeves and cutters), which is based on evidence that ropes with breaking strengths of 1,700lbs could reduce the number of life-threatening entanglements by allowing whales to swim free more easily.[369] The National Marine Fisheries Service requires all trap/pot gear to use weak links at the buoy line since the early 2000s. In Canada, weak rope will be mandatory by the end of 2022 followed by maximum rope diameters, sinking rope and reductions in vertical and floating rope[367] whereas the US has mandated sinking groundlines since 2007.[370] Since then, 91 per cent of North Atlantic right whale entanglements involves end lines (lines that connect bottom gear to the surface) and as such, the major challenge and opportunity remain to remove all ropes in the water column.[368]

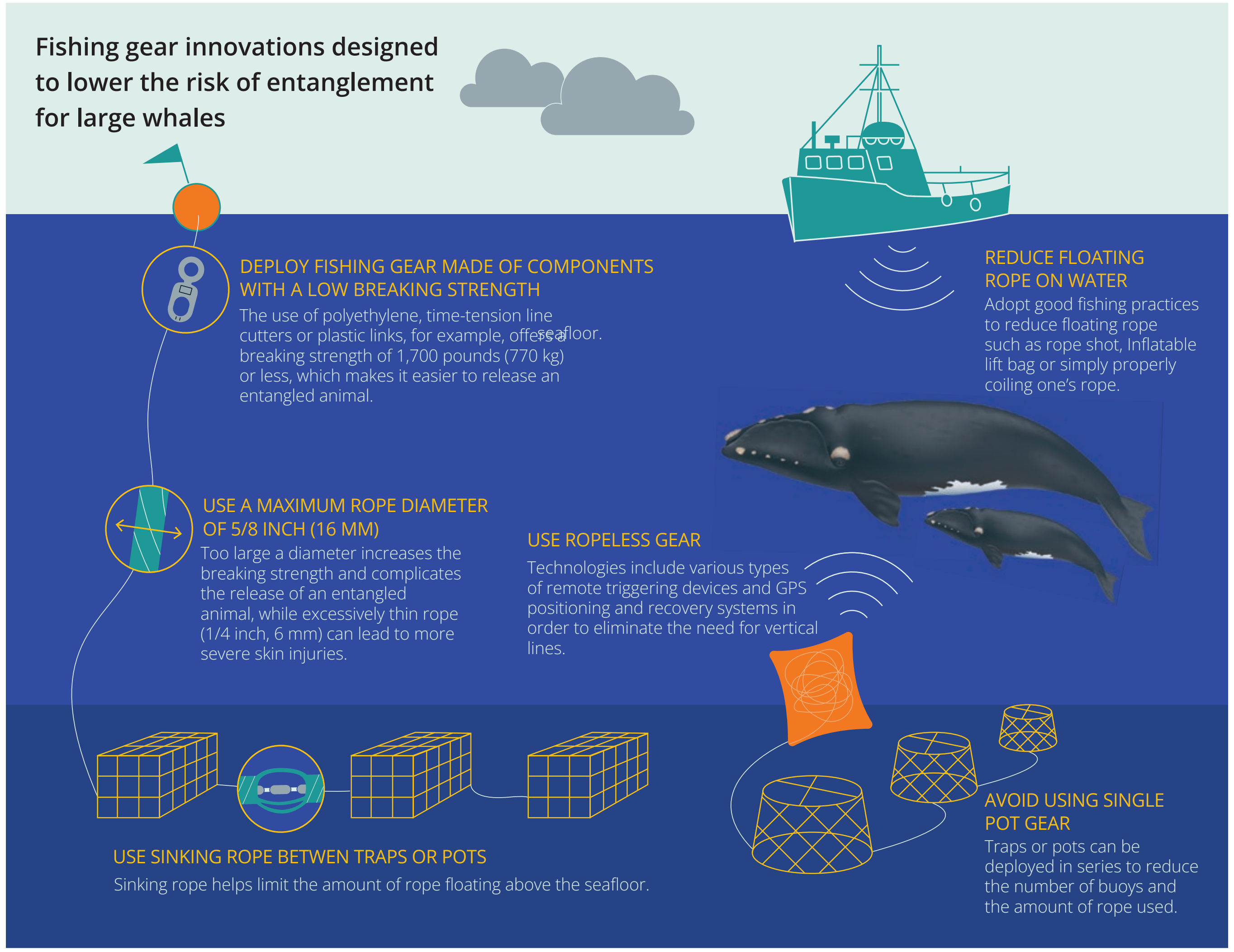


Figure 28: An illustration of innovations designed to lower the risk of entanglement for large whales - including ropeless fishing.[432]
North Atlantic right whale illustration © Uko Gorter

© naturepl.com / Tony Wu / WWF

IMPROVING WHALE CONSERVATION THROUGH COOPERATIVE POLICY ACTION

Whale conservation for the 21st century will require a new approach, tools and enhanced cooperation between communities, science, civil society, industry, states and intergovernmental bodies. We highlight some emerging opportunities for action to address cumulative impacts. We present a broad overview how these actions could be coordinated, implemented, monitored and evaluated.

A PATHWAY FOR IMPROVING WHALE CONSERVATION THROUGH COOPERATIVE POLICY ACTION

1. GENERATING EVIDENCE-BASED KNOWLEDGE AND SOLUTIONS

through development of science-based conservation plans and strategies involving the broadest range of expertise and responsibilities.

2. COORDINATING APPROACHES AND EFFORTS TO DELIVER IMPACT

through global and regional leadership to effectively conserve whales using multiple jurisdictions facing threats from different sources.

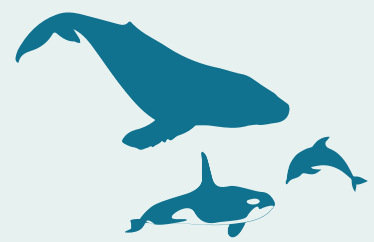
3. DELIVERING CONSERVATION OUTCOMES

by ensuring relevant state and private actors take appropriate conservation actions both individually and collectively, particularly through enhanced cooperation and shared decision-making.

IWC: Continue efforts to address bycatch, ship strikes, underwater noise, climate change and small cetacean conservation issues while coordinating member state commitments to conserve whales. Encourage further collaboration with relevant international bodies as well as the private sector.

CMS: Continue to deliver coordination between range states of migratory whales, through dedicated instruments that drive effective, science-based threat reduction and conservation impact.

CBD: Focus area-based conservation on networks of protected or conserved areas (through multiple mechanisms such as MPAs, OECMs), ensuring ecological connectivity and ecosystem function across all jurisdictions. Identify areas of ecologically or biologically significant marine areas for cetaceans based on IUCN IMMAs and KBAs, which include areas both within EEZs and beyond national jurisdiction.



IUCN:

Continued identification of ritical habitats for cetaceans and monitoring of populations through the Species Survival Commission and the IUCN Red List. Through World Commission on Protected Areas, continued leadership in international coordination of knowledge of MPAs and connectivity conservation.

KEY BIODIVERSITY PARTNERSHIP:

Identification of KBAs for cetaceans including critical breeding, feeding and migration areas. WWF and partners encourages the use of KBA datasets to inform MPA design and for use by the private sector conducting business in and around these areas.

GLOBAL GHOST GEAR INITIATIVE:

Coastal states, private sector and civil society commit to joining this international initiative focused on solving the problem of lost and abandoned fishing gear worldwide.

SCIENCE COMMUNITY:

The UN Decade of Ocean Science is a catalyst to provide policymakers with science-based solutions. Make data publicly available to inform decisions based on the best available knowledge. Where possible, work with Indigenous and local communities to co-produce new knowledge on cetacean migration routes and timing.

UNFCCC: Protect and restore whale populations as a nature-based solution to combat climate change and enhance ocean productivity.

RFMOs: Implement national and regional cetacean management plans as part of efforts to reduce bycatch and allow populations to recover and thrive.

CCAMLR: Deliver commitment to implement a network of MPAs to safeguard key habitats for migratory whales and critical foraging habitat in the Southern Ocean.

IMO: Implement guidelines to reduce impacts of underwater noise and shipstrikes to ensure effective implementation by the shipping industry.

UN BBNJ:

Finalize negotiations of and implement an ambitious new global treaty to drive enhanced cooperation to ensure conservation and sustainable use of biodiversity in areas beyond national jurisdiction in 2022. Crucially, the treaty needs to establish a process for the designation of MPAs.

REGIONAL SEAS ORGANIZATIONS/TREATIES:

Increase cooperation to co-design and implement science-based regional management plans for cetaceans to allow populations to recover and thrive.

NEW GLOBAL PLASTICS TREATY:

Include elimination of lost and abandoned fishing gear in the global Plastic Treaty and by the fisheries sector.

ARCTIC COUNCIL:

Support ArcNet's ocean-scale ambitions and contribute to the establishment and effective management of a network of protected and conserved marine areas across the Arctic Ocean.

PRIVATE SECTOR:

Corporations and financial institutions, when setting and implementing science-based targets for nature, can include conservation efforts of migratory whale populations.

SHIPPING:

- Invest and lead in innovation of quiet ship design and retrofitting technology to reduce noise impacts on cetaceans.
- Where possible, use IMMAs and KBAs as guides and commit to move ships away from key whale habitats.
- Follow existing voluntary guidelines in slowdown areas to reduce underwater noise and risks of ship strikes.
- In new ship builds, implement quiet design standards and retrofit older vessels to reduce underwater noise pollution.

FISHING

Make commitments to enhanced observation and Remote Electronic Monitoring of fisheries and implementing innovations in gear types to eliminate bycatch and adhere to (voluntary) closures.

COASTAL DEVELOPMENT, INFRASTRUCTURE & EXTRACTIVE INDUSTRIES:

Follow the mitigation hierarchy with focus on the 'avoid' step to prevent destruction or degradation of whale habitats and corridors, including impacts such as underwater noise.

COASTAL STATES

- 30x30: Protect and conserve at least 30 per cent of our ocean by 2030.
- Develop multi-national and regional action plans with measures to protect critical cetacean habitat.
- Implement innovative approaches to dynamic ocean management to reduce threats to at-risk populations.
- Where possible, identify and move shipping lanes away from key whale habitats, implementing mandatory slowdown areas in major shipping lanes. Incorporate slow steaming where possible to reduce underwater noise and ship strikes.
- Eliminate unsustainable, unregulated and illegal take of cetaceans.

FLAG STATES

Nationalities of merchant and fishing vessels work in all sectoral fora (IMO, RFMOs, ISA) to ensure that all obligations under all relevant agreements are being implemented to effectively conserve cetaceans throughout their ranges.

KEY ORGANIZATIONS, CONVENTIONS AND TREATIES FOR ENHANCED COOPERATION TO DEVELOP SCIENCE-BASED CONSERVATION PLANS AND STRATEGIES TO DELIVER CONSERVATION OUTCOMES

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International Whaling Commission (IWC)

The IWC is an intergovernmental organization charged with delivering the International Convention for the Regulation of Whaling. The convention (1946) and its protocol (1956) established an international regulatory system for whaling that was intended to ensure effective conservation of commercially exploited great whale populations. The IWC has a secretariat, based in Cambridge, UK, that supports the work of the Commission and its subsidiary bodies. The secretariat is tasked with implementing the Commission's decisions through management measures, among other things, to protect threatened species, designate specific areas as sanctuaries, set catch limits and minimum sizes, ensure protection of calves and females accompanied by calves, document threats, recommend required research and conservation measures, compile statistics and biological records, coordinate funding scientific research, and publish scientific results.[429,430]

The mission of the IWC is as follows: "The IWC is the global body charged with the conservation of whales and the management of whaling. The IWC currently has 88 member governments from countries all over the world. The Commission's role has expanded since its establishment in 1946. In addition to regulation of whaling, today's IWC works to address a wide range of conservation issues including bycatch and entanglement, ocean noise, pollution and debris, collision between whales and ships, and sustainable whale watching."[371]

In 1982, the IWC decided to stop commercial whaling on all whale species and populations from the 1985/1986 season onwards. The commercial whaling moratorium remains in place today, although some nations still conduct commercial whaling - Japan (which is no longer a member of the IWC), Norway and Iceland. Two whale sanctuaries have been created under the framework of the International Convention for the Regulation of Whaling: the Indian Ocean Sanctuary (1979) and the Southern Ocean Sanctuary (1994). The latter includes the waters around Antarctica, the main feeding area for great whales in the southern hemisphere.

Currently, the IWC has both a Scientific Committee and a Conservation Committee, as well as several working groups with world-leading experts designing innovation solutions. The IWC's ship strikes working group developed its 2017–2020 strategic plan to mitigate the impacts of ship strikes on the cetacean populations. In 2016, the IWC endorsed the Bycatch Mitigation Initiative with the goal of identifying conservation priorities, furthering the testing innovation in fishing gear and methods, sharing of expertise and engaging with other relevant organizations.

IWC does not regulate small cetacean hunts. However, it is engaged in a range of research and conservation programmes focused on small cetaceans. In 2015, the Small Cetacean Task Team initiative was launched. Task Teams are designed to instigate urgent action when a significant and swift decline has been observed in a small cetacean population or species. So far, four task teams have formed, each working closely and flexibly with local experts on the ground.

WWF continues to support the IWC as the global body with primary responsibility for the conservation of whales and the management of whaling, and urges increased collaboration with other organisations and conventions, with the mandate to promote biodiversity and reduce threats to cetaceans. We support IWC efforts to address bycatch, ship strikes, underwater noise, and small cetacean conservation issues, the strengthening of the IWC Scientific and Conservation Committees, other conservation-based initiatives of the IWC, and developing Conservation Management Plans for the most endangered whales and small cetaceans.

Convention on the Conservation of Migratory Species of Wild Animals (CMS)

This convention was adopted in 1979. Parties of the Convention recognize the need to adopt appropriate measures for the conservation of migratory species and their habitats. The convention provides strict protection for endangered migratory species listed in Appendix I, where most species of baleen whales, the sperm whale and several species of dolphins are included. Appendix II contains 44 cetacean species that are considered to have an unfavourable conservation status, such as both minke whale species and several harbour porpoise populations (including the Baltic).[372] Currently there are 131 countries that are signatories to this agreement.

Primary principles of the CMS are that states are the protectors of the migratory species that live within or pass through their jurisdictions, and international cooperation of states is essential for the conservation of migratory species.[373]

The convention has issued several resolutions related to whale and dolphin conservation, management, meat consumption, whale-watching and guidance of bycatch reduction. Recently, CMS published guidelines for the safe and humane handling and release of bycaught small cetaceans from fishing gear.[374]

CMS acts as a framework convention, separately providing legally binding international instruments and other agreements between range states for migratory species. In the field of marine mammals, three agreements have been developed for the conservation of whales and dolphins:

1. Agreement on the Conservation of Small Cetaceans of the Baltic, Northeast Atlantic, Irish and North Seas (ASCOBANS);
2. Agreement on Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area (ACCOBAMS); and
3. Memorandum of Understanding for the Conservation of Cetaceans and their Habitat in the Pacific Islands Region.

Convention on Biological Diversity (CBD)

This convention was signed in Rio de Janeiro in 1992. Through the CBD, the world community has recognized the negative effects of the loss of biological diversity on the quality of life, the survival of humanity and life in general on the planet. The convention addresses different aspects related to marine and coastal biodiversity such as invasive species, protected areas and an ecosystem approach, among others. Over the last 10 years the CBD has been leading a process to identify ecologically or biologically significant areas (EBSAs), which include areas both within EEZs and beyond national jurisdictions. In addition, the Sustainable Ocean Initiative seeks to bring together key actors in RSCAP and RFMO networks to help strengthen cooperation between member states to more effectively deliver ecosystem-based management.[375]

In establishing the EBSA identification process, states were clear that the CBD's role should be limited to marshalling the science and then passing on the information to Parties to the Convention and international bodies with the competency to take sectoral management action (RFMOs, IMO and International Seabed Authority – ISA – for areas beyond national jurisdiction).

The EBSA identification process involves maintaining a set of eligibility criteria, holding regional scientific expert workshops to describe qualifying areas, and preparation of workshop reports that can then be used by the CBD Conference of the Parties (COP) to formally identify areas for inclusion in its EBSA repository. These reports upon which identification was based can then be passed on to the relevant states and bodies to inform their work in exercising their management responsibilities and can contribute to the conservation and protection of critical habitats for whales and their prey species.

Insofar as the CBD is a "universal" treaty, effective coordination between IWC, CMS and CBD has the potential to engage more states than just those party to CMS or IWC. This is an important consideration given the extent to which coastal states need to be involved in the development and implementation of whale conservation and recovery plans with respect to their management of fisheries within their EEZs (for shipping, collective decision-making through IMO remains the principal approach to management).

While the Aichi Biodiversity targets of protecting 10 per cent of our ocean by 2020 were missed, there is growing optimism and momentum that we can work toward a new target of 30 per cent protected areas and OECMs by 2030, as cited by the Kunming Declaration by the CBD in 2021.[376]

A new UN treaty on Biodiversity Beyond National Jurisdiction (BBNJ)

The global ocean can be divided into areas within the national jurisdiction of states (national waters), usually extending 200 nautical miles (370km) offshore, and those in international waters, called Areas Beyond National Jurisdiction (ABNJ). Approximately 61 per cent of the sea surface is defined as ABNJ. Whale conservation in ABNJ is highly challenging since:

- marine mammals are highly mobile and often occur in the open ocean;[377]
- there is still limited knowledge of the distribution of many species; and
- only limited mechanisms exist for conservation and management in these areas.[378,379]

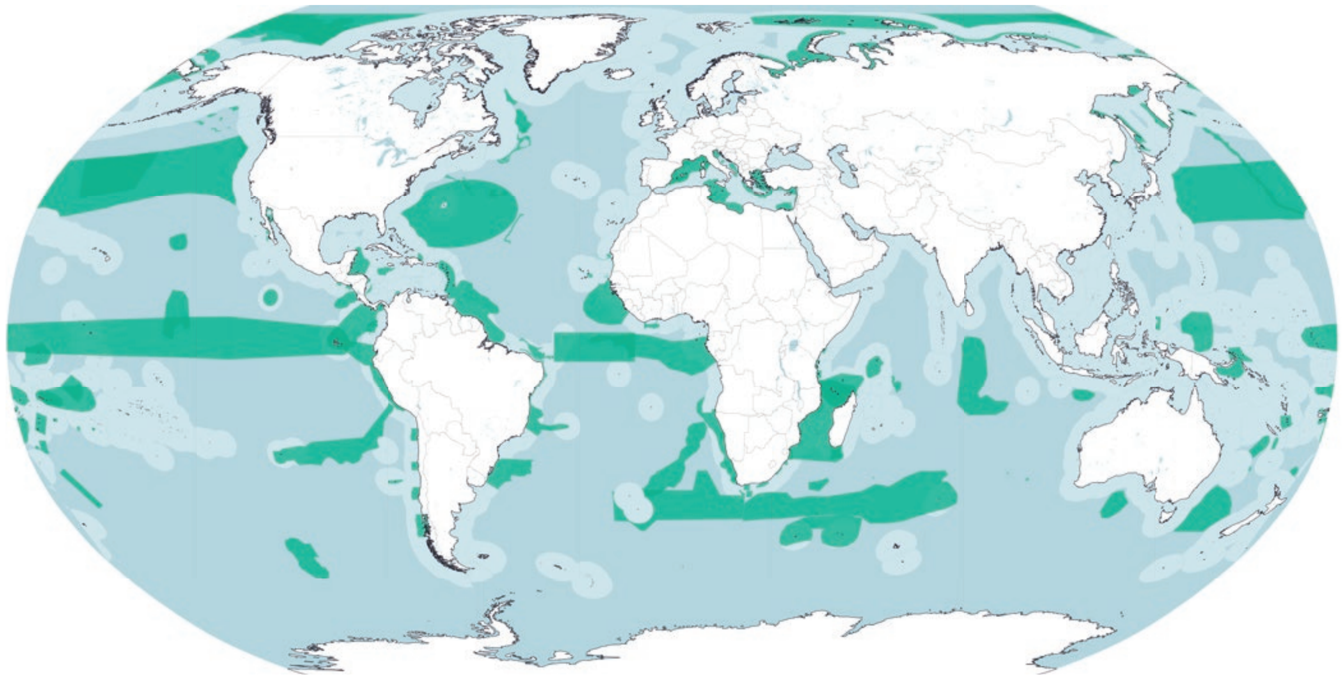

Figure 29: EBSAs globally. See Appendix 3 for more information.

Although it is still a legal instrument in development, the new agreement on Biodiversity Beyond National Jurisdiction (BBNJ) will lay the foundations for the future management of marine biodiversity in ABNJ. The objective of this agreement is "to ensure the long-term conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction through effective implementation of the relevant provisions of the Convention and further international cooperation and coordination".[380] The agreement is based on several principles such as common heritage, equity, precaution, ecosystem and integration approaches. There are four main components to this agreement:

1. Marine genetic resources, including questions on the sharing of benefits;
2. Area-based management tools, including MPAs;
3. Environmental impact assessments; and
4. Capacity-building and transfer of marine technology.

A strong BBNJ agreement is essential because whale migration can occur between ABNJ and national waters and is subject to a variety of threats, thus protection measures are needed to address cumulative impacts. For whale conservation and recovery, having an international body with the competency to designate MPAs in ABNJ is a key ambition.

The agreement can provide the framework for the "enhanced cooperation" needed between states and international bodies to ensure the conservation and recovery of whales. As whales migrate across jurisdictions, a large number of individual coastal, flag and port states are involved and these need to share the ambition if effective action is to be taken with the myriad of sub-regional, regional and global bodies across multiple sectors of maritime activity.

This new agreement will complement existing international agreements dealing with high seas fisheries, deep-sea mining (should it be allowed to occur), pollution and conservation, and will therefore set the basis for a holistic, integrated and ecosystem-based governance of the ocean.

A Conference of the Parties (COP), likely to be established by the BBNJ agreement, would have the responsibility to foster enhanced cooperation not only between states but between the bodies established by various other agreements. This would address a key concern of states that "silo" decision-making by sectoral bodies is unhelpful to achieve necessary conservation and cooperation outcomes.

WWF is proposing that the BBNJ COP be given the power of delegation to establish regional arrangements that would be given the mandate to implement the provisions of the BBNJ agreement (including designating high seas MPAs and facilitating enhanced cooperation). Such a regional delegation of global responsibilities would be done in response to a request from states with an interest in the conservation and sustainable use of ABNJ biodiversity in that region, where "region" is at the scale of ocean basins – seven globally – being the scale at which ecological, commercial and diplomatic interests best align.


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International Maritime Organization (IMO) agreements

The IMO Is the United Nations' specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. In the framework of the IMO, countries have signed 51 binding agreements, 21 of which are related to environmental issues such as water and air pollution, dredging and invasive species, among others. The Marine Environment Protection Committee (MEPC) is the technical body on marine pollution-related matters. The MEPC incorporated the issue of ship strikes of cetaceans in 2009, elaborating a guidance document to minimize the risk of ship strikes with cetaceans.[381]

The IMO has also designated Particularly Sensitive Sea Areas (PSSAs) to protect vulnerable ecosystems from shipping in the Great Barrier Reef, Australia (1990), including the Torres Strait (2005) and southwest coral Sea (2015); the Sabana-Camagüey Archipelago, Cuba (1997); Malpelo Island, Colombia (2002); the sea around the Florida Keys, United States (2002); the Wadden Sea, Denmark, Germany, Netherlands (2002); Paracas National Reserve, Peru (2003); Western European Waters (2004); Canary Islands, Spain (2005); the Galápagos Archipelago, Ecuador (2005); the Baltic Sea area, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden (2005); the Papahānaumokuākea Marine National Monument, United States (2007); the Strait of Bonifacio, France and Italy (2011); the Saba Bank, in the northeastern Caribbean area of the Kingdom of the Netherlands (2012); the Jomard Entrance, Papua New Guinea (2016); and the Tubbataha Reefs Natural Park, the Sulu Sea, Philippines (2017).[382]

The IMO has associated protective measures that can be applied within designated PSSAs. They are aimed at preventing, reducing or eliminating threats to the area and may include ship routing and reporting systems, pilotage regimes or vessel traffic services.[383]

In 2014, the IMO MEPC adopted a set of guidelines on the reduction of underwater noise from commercial shipping. In June 2021, the IMO MEPC agreed to a new work item to review these guidelines and identify next steps, with a target completion year of 2023 (MEPC 76/WP.1/Rev.1).[384]

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC is the United Nations entity supporting the global response to climate change. It supports a complex architecture that serves to advance the implementation of the convention, the Kyoto Protocol (1997) and the Paris Agreement (2015). In 2019, the Intergovernmental Panel on Climate Change, at the request of the UNFCCC, published its Special Report on the Ocean and Cryosphere, a synthesis report bringing together current knowledge and understanding.

Besides being impacted by climate change, whales are also an important solution to combat climate change by acting as carbon sinks.[2] This can occur directly through whale falls, as on average a single large whale is estimated to store an equivalent of 33 tons of carbon in its body. The other route is stimulating phytoplankton growth by fertilization through whale feces, both through vertical (diving) and horizontal (migration) movement.[25] Globally, phytoplankton is estimated to capture 40 per cent of carbon emissions and produce 50 per cent of oxygen. In this way, recovering whale numbers could help restore nutrient cycling and thereby increase ocean productivity, including carbon capture.[385] This demonstrates that investing in whale conservation is a nature-based solution.

KEY ACTORS IN ENHANCED COOPERATION TO DEVELOP SCIENCE-BASED CONSERVATION PLANS AND STRATEGIES TO DELIVER CONSERVATION OUTCOMES

International Union for the Conservation of Nature (IUCN)

IUCN is unique among intergovernmental bodies in that membership is open to both government agencies of states and non-government organizations. It holds its congress every four years where negotiation and adoption of resolutions sets policy and strategic direction for the executive delivered through various programmes and the work of its expert commissions. During the last Congress, started in October 2020 and finalised in September 2021 due to the COVID-19 pandemic, several motions were passed supporting the conservation of ecological corridors.[386–390]

The IUCN congress, programmes and commissions provide the principal global framework through which the world's conservation community organizes its work and sets its directions, especially in addressing emerging issues.

Key IUCN networks critical to inform conservation outcomes include the following:

- IUCN World Commission on Protected Areas (WCPA): The commission develops knowledge-based policy, advice and guidance on the full suite of issues surrounding protected areas through the establishment of specialist groups and task forces. It brings together global experts to find solutions for programme priorities, including global protected area standards and best practice guidelines. IUCN-WCPA Best Practice Protected Area Guidelines are the world's authoritative resource for protected area managers. The guidelines also assist national governments, protected area agencies, non-government organizations, communities and private sector partners in meeting their commitments and goals, and especially the Convention on Biological Diversity's Programme of Work on Protected Areas.[391]

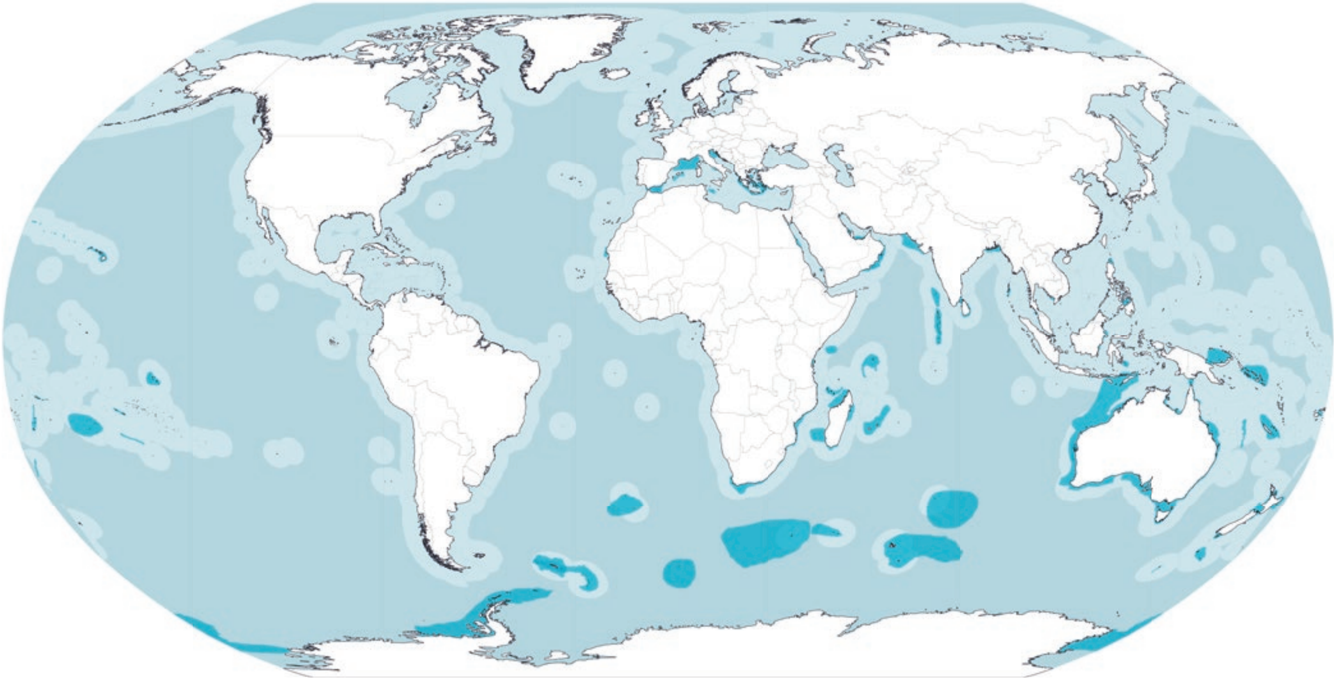

Figure 30: Current IMMAs worldwide. See Appendix 3 for more information.

- International Marine Mammal Protected Areas Task Force: Important Marine Mammal Areas (IMMAs) are a tool developed by the Marine Mammal Protected Areas Task Force of the IUCN Species Survival Commission and World Commission on Protected Areas.[392,393] IMMAs highlight areas that are important for one or more marine mammal species and have the potential to be managed for conservation. In this context, "important" means "any perceivable value, which extends to the marine mammals within the IMMA, to improve the conservation status of those species or populations". IMMAs thus provide an objective and consistent framework to identify the most critical marine mammal habitats to prioritize their conservation and inform the designation and management of networks of MPAs.[263]

- IUCN Species Survival Commission Cetacean Specialist Group (SSC-CSG): Since the 1960s, the Cetacean Specialist Group (CSG) has played a major role in identifying conservation problems for the world's whales, dolphins and porpoises. It functions as a catalyst, clearing house and facilitator for cetacean-related research and conservation action with more than 140 members. The guiding premise is that conservation ultimately depends on good science, and the group's credibility and value are based on maintaining high standards of scientific rigor.[394]

- IUCN Red List: Of particular note where the great whales are concerned is the IUCN's longstanding role in maintaining the Red Lists of Threatened Species. It remains the world's authority on such matters and is critical to monitoring cetacean populations. Currently, out of the 90 recognised cetacean species, 4 are designated as Critically Endangered, 11 as Endangered, 7 as Vulnerable, 10 as Near Threatened, 49 as Least Concern and 9 as Data Deficient.[395]

Migratory Connectivity in the Ocean (MiCO)

The distributions of migratory species in the ocean span local, national and international jurisdictions. Across these ecologically interconnected regions, migratory marine species interact with anthropogenic stressors throughout their lives. Innovations in animal tracking technology are changing the way we think about how the world's oceans are connected and about the migratory connectivity of populations and species.[373]

MiCO is a consortium of more than 50 organizations led by the Marine Geospatial Ecology Lab (MGEL) of Duke University, developing an extensive open-access system with the end goal of connecting global processes with actionable knowledge on migratory connectivity to inform worldwide conservation and sustainable use efforts. These data continue to broaden our understanding of the connectivity generated by migratory marine species – the critical habitats they depend on throughout their life cycles, and the pathways between them.

However, while the amount of data continues to grow exponentially, efforts to synthesize and provide access to information on migratory connectivity for management and policy has lagged behind. By transforming these data into actionable knowledge, MICO is hoping to provide data for international management and policy frameworks to aid in the conservation and sustainable use of migratory species.[396]

SOME AREA-BASED MANAGEMENT TOOLS THAT COLLECTIVELY WILL SECURE IMPORTANT OCEAN HABITATS AND BLUE CORRIDORS

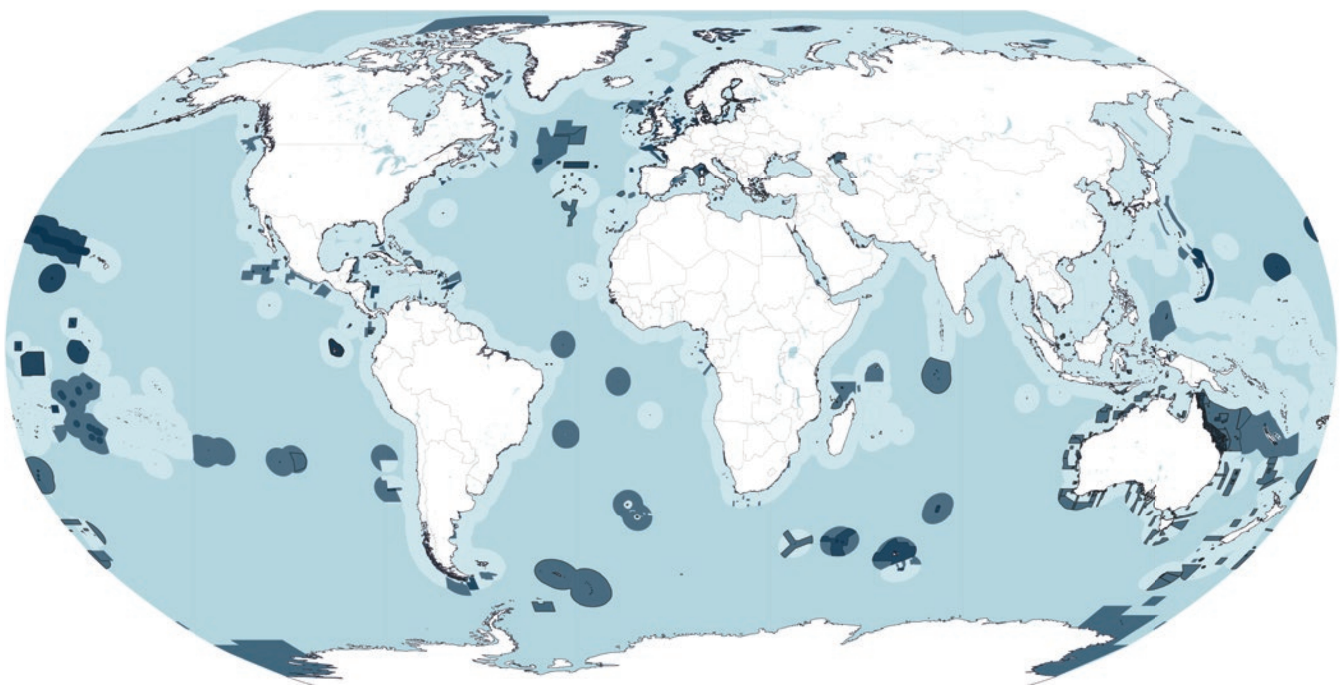

Figure 31: A global view of marine protected areas worldwide. See Appendix 3 for more information.

Marine Protected Areas (MPAs)

MPAs are conservation tools intended to protect biodiversity, promote healthy and resilient marine ecosystems, and provide societal benefits.[18]

Within national waters, MPAs have been a powerful tool for reducing habitat loss, preserving biodiversity and increasing nature's resilience to multiple stressors, including climate change, for several decades.[397–399]

Global policymakers had pledged to protect 10 per cent of the world's marine and coastal areas by 2020 as part of the UN Sustainable Development Goals framework. However, the global coverage of MPAs is, in November 2021, only 7.91 per cent of the ocean.[400] Further, activities like fishing are still allowed in many MPAs, limiting their effectiveness.[401] Strongly or fully protected areas cover only 2.7 per cent of the ocean. The IUCN recommends that 30 per cent of the ocean be protected from extractive activities[391] as a way to support better climate change mitigation and nature conservation.[402]

WWF is collaborating with many stakeholders to protect 30 per cent of our global ocean by 2030 through effectively and equitably managed, ecologically representative and well-connected systems of marine protected areas and other effective area-based conservation measures.[391] These include ensuring that the areas traditionally and collectively governed by indigenous peoples and local communities are appropriately recognized and secured and their right to free, prior and informed consent is respected. MPAs are often referred to as a nature-based solution to support global efforts toward climate change adaptation and mitigation.[40,403]

MPAs can be more easily created by governments in national waters where there are dedicated legal and enforcement systems in place. On the high seas, it is more difficult to create MPAs due to the complex legal framework in place.[379,404] As such, the percentage of MPAs created within national waters is much higher than that for ABNJ.[405] National waters represent 39 per cent of the global ocean and

at present, 17.21 per cent of these waters are designated as MPAs. In contrast, only 1.18 per cent of ABNJ, which makes up the remaining 61 per cent of the global ocean, has been established as protected areas.

At present, international discussions are underway to establish ways of simplifying the process to create MPAs in ABNJ.[400] Nonetheless, there are already some MPAs in ABNJ. CCAMLR has committed to the creation of a representative system of MPAs throughout the Southern Ocean, where WWF is currently working with partners to secure high-seas MPAs. This already includes one of the world's largest MPAs – the Ross Sea Region MPA.[400,406]

Additionally, there are increasing calls for mobile MPAs, whose boundaries are dynamic across space and time. [24,407,408] These could be especially effective for migratory species like whales.

Dynamic management tools include the designation of seasonal management areas where only certain types of high-risk activities are regulated during the times of year when the target cetacean population is present and/or engaged in behaviours critical to their life cycle or survival.[1,299] Examples include "time-area closures", where high-risk areas are closed to fishing at certain times. These and other management options can be targeted to reduce impacts of shipping (ship strikes, underwater noise) and fisheries bycatch, thus protecting critical habitats.

Other Effective Area-based Conservation Measures (OECMs)

The CBD defines an OECM as "a geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in-situ conservation of biodiversity with associated ecosystem functions and services and where applicable, cultural, spiritual, socio–economic, and other locally relevant values".[409] In-situ conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

In many cases, the difference between an OECM and a protected area relates to its objectives: a protected area must have biodiversity conservation as a primary objective, whereas an OECM must deliver biodiversity conservation regardless of its primary objectives. Like protected areas, OECMs can align with any of the IUCN governance types.[410] Because this definition was only recently adopted, most countries have not yet provided data to the World Database on OECMs. The challenge for governments and other stakeholders will be in identifying OECMs, and supporting them to maintain their conservation benefits in the long term.[411,412]

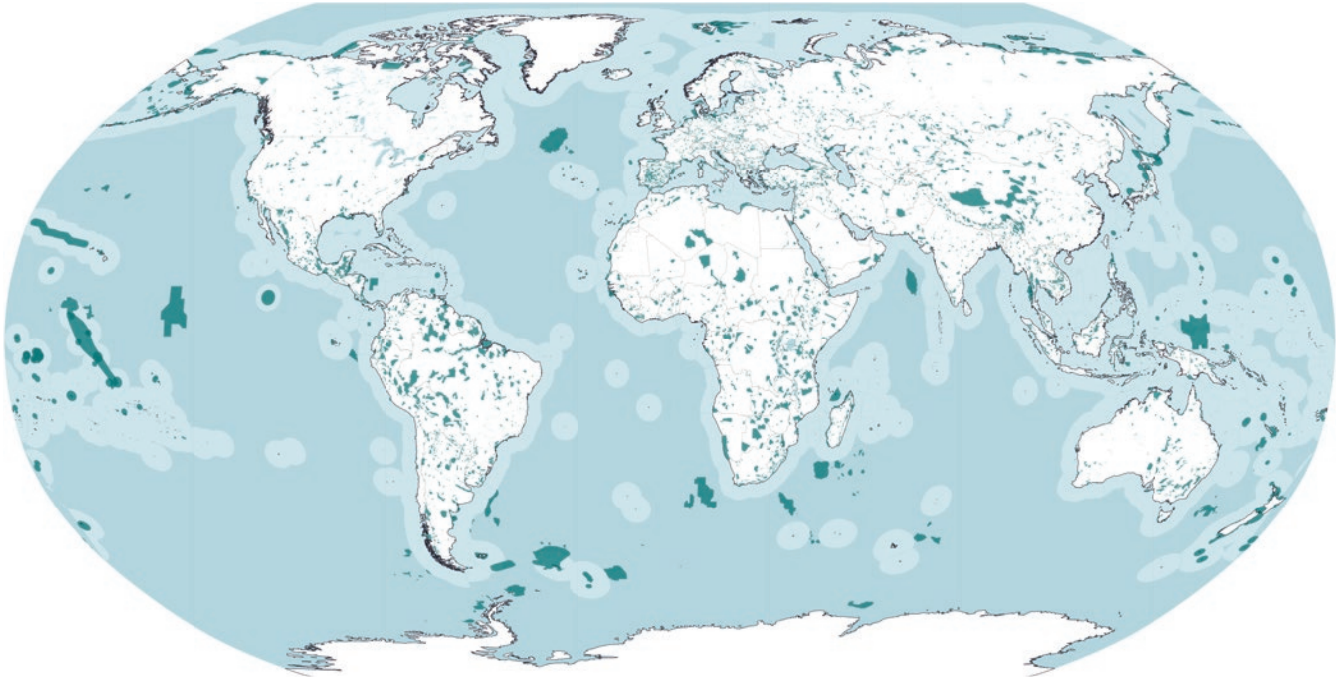

Figure 32: Map. Marine KBAs worldwide. See Appendix 3 for more information.

Key Biodiversity Areas (KBAs)

Key Biodiversity Areas (KBAs) are the most important places in the world for species and their habitats. Faced with a global environmental crisis we need to focus our collective efforts on conserving the places that matter most. The KBA Programme supports the identification, mapping, monitoring and conservation of KBAs to help safeguard the most critical sites for nature on our planet – from rainforests to reefs, mountains to marshes, deserts to grasslands and to the deepest parts of the oceans.[413]

The Key Biodiversity Area Partnership – an ambitious partnership of 13 global conservation organizations – is helping prevent the rapid loss of biodiversity by supporting nationally led efforts to identify these places on the planet that are critical.

By mapping these most important sites on Earth, and providing information about the wildlife living there, private industry, governments and other stakeholders can make the best decisions about how to manage that land (or waters), where to avoid development, and how best to conserve and protect the animals and plants for which the sites are so important.[414]

For cetaceans in particular it is crucial that key breeding, migration and foraging areas are identified. In 2021, the first ever KBA was established for sei whales (*Balaenoptera borealis*). Ongoing research over five years revealed that the Falkland Islands are a globally important hotspot for recovering populations of endangered sei whales in the summer months.[415]

Marine spatial planning

Marine spatial planning (MSP) provides a comprehensive framework for the mapping and management of multiple uses of the marine environment (e.g. shipping, military training, aquaculture and fishing) and has the potential to minimize environmental impacts and reduce conflicts among users.[127,416] MSP must be based on ecological principles to sustain ecosystem integrity. For example, one outcome of decision-making should be healthy populations of top predators and prey species that affect the structure and stability of food webs and species that have strong effects on community structure and function.[417]

Spatially explicit risk assessments are a basic requirement of MSP because they link the distribution of these key species to the potential effects and distribution of anthropogenic activities.[127]

For example, a research study assessed the risk of ships striking humpback whales, blue whales (Balaenoptera musculus) and fin whales in shipping routes off Southern California (United States).[127] They developed whale-habitat models and mapped ship-strike risk for the alternative shipping routes proportional to the number of whales predicted by the models to occur within each route. They found the route with the lowest risk for humpback whales had the highest risk for fin whales and vice versa. Risk to both species may be ameliorated by creating a new route south of the northern Channel Islands and spreading traffic between this new route and the existing route in the Santa Barbara Channel.

Dynamic ocean management (DOM) is a type of MSP in which management decisions are updated in response to changing environmental, biological or socioeconomic conditions. It balances trade-offs between conservation and marine resource use, and will become increasingly important as the climate continues to change.[138] Hausner et al. (2021) examined the same shipping route looking at various strategies to mitigate ship strikes with blue whales. These included a "daily strategy" that implemented speed reductions in response to whale habitat conditions on a daily basis, and a "seasonal strategy" that implemented speed reductions in response to whale habitat conditions on a seasonal basis – with a "fixed strategy" that implemented speed reductions for a fixed time period each year, irrespective of environmental conditions. They found reviewing data over a 17-year period, there was a clear trade-off between protecting whales and enabling unrestricted vessel activities. However, both DOM strategies improved outcomes compared to a fixed vessel speed reduction period.

Marine connectivity conservation

Connectivity conservation is widely recognized as a key requirement for ensuring effective MPA networks and sustaining essential ecological processes of the planet's oceans.

The marine environment poses special challenges for connectivity conservation and has its own specialized scientific expertise, technologies and management tools. Marine space is unique not only in its dynamic natural features and processes but also in the science and management challenges posed by deep off-shore waters, linkages with land and the high seas, different tenure systems and greater scientific uncertainty. However, connectivity research in marine systems remains much less advanced than for terrestrial systems and the science is less-well developed. The IUCN WCPA Connectivity Conservation Specialist Group has established the Marine Connectivity Working Group to address this imbalance and brings together marine experts from multiple disciplines to collaborate around the world.[418]

To design effective and resilient MPAs and coherent networks of MPAs,[419] it is necessary to take into account ecological connectivity (generally referred to as "connectivity"), which allows populations to thrive and biodiversity and ecosystem services to be maintained.[420]

The IUCN recently published guidelines to improve marine ecological connectivity in MPA design. The CMS adopted a policy resolution in 2020 stating that "ecological connectivity is the unimpeded movement of species and the flow of natural processes that sustain life on Earth"[421] and should be a key factor in the conservation of management units, including in the marine environment.[420]

Whale migrations demonstrate the need to protect their blue corridors and manage growing impacts in an ecologically connected network.

WHAT ARE THE TYPES OF ECOLOGICAL CONNECTIVITY?

Ecological connectivity for species: The functional movement of populations, individuals, genes, gametes and propagules between populations, communities and ecosystems, as well as the structural connection of non-living material from one location to another.

Functional connectivity for species: A description of how well genes, gametes, propagules or individuals move through land, freshwater and the ocean.

Structural connectivity for species: A measure of habitat permeability based on the physical features and arrangements of habitat patches and stepping stones, disturbances, and other land, freshwater or ocean elements presumed to be important for organisms to move through their environment. Structural connectivity is used in efforts to restore or estimate functional connectivity where measures of it are lacking.

Ecological corridors: A clearly defined geographical space that is governed and managed over the long term to maintain or restore effective ecological connectivity. The following terms are often used similarly: "linkages", "safe passages", "ecological connectivity areas", "ecological connectivity zones" and "permeability areas".

Ecological network (for conservation): A system of core habitats (terrestrial or marine protected areas, OECMs and other intact natural or semi-natural areas), connected by ecological corridors, which is established, restored as needed and maintained to conserve biological diversity in systems that have been fragmented.[420]

THE SUSTAINABLE BLUE ECONOMY: OPPORTUNITIES AND RISKS

The ocean is a biologically diverse and highly productive system. It is an immense source of materials, food, energy and ecosystem services. According to OECD projections,[422] by 2030, the "blue economy" – defined as all economic sectors which have a direct or indirect link to the ocean – could outperform the growth of the global economy as a whole, both in terms of value added and employment. In the coming decade, marine energy, marine biotechnology, coastal tourism, transport and food production sectors could offer unprecedented development and investment opportunities. However, there is increasing evidence that losses in the ocean's natural capital resulting from unsustainable economic activity is eroding the resource base on which such growth depends.[423]

A sustainable blue economy fits within the boundaries of our ocean's ecosystems. Truly integrated maritime policies, adequate economic and legislative incentives, supportive public and private financial and investment flows, as well as successful implementation of ecosystem-based MSP are all important means to help us get there. Healthy ecosystems, well-managed MPAs and good environmental status must be the basis for sustainable development, not separated from it.

WWF works to ensure that the blue economy is tied to sustainable economies on both land and at sea – that is, an economy that provides social and economic benefits for current and future generations, that restores, protects and maintains diverse, productive and resilient marine ecosystems, and that is based on clean technologies, renewable energy and circular material flows.

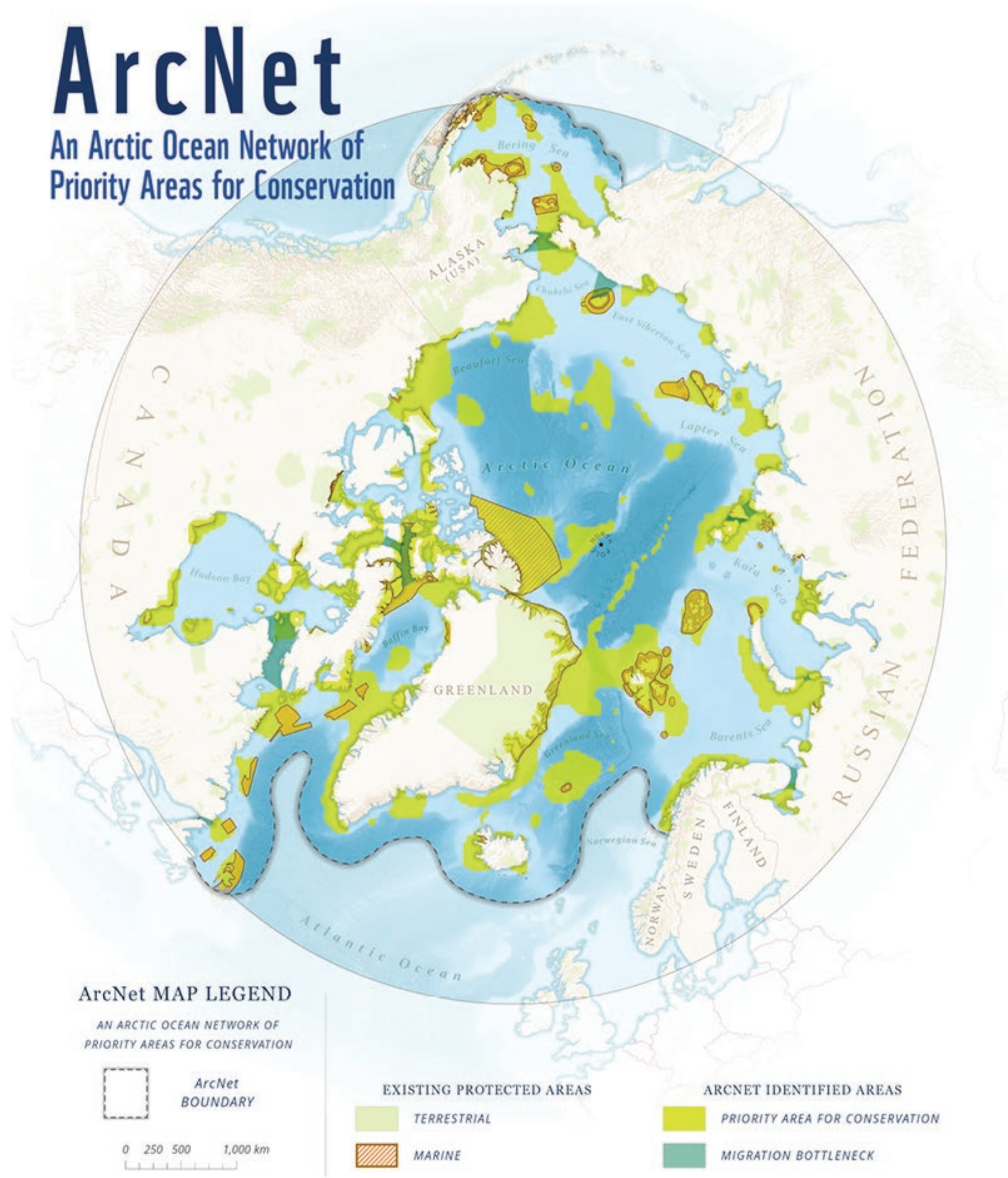

Figure 33: ArcNet. For more information visit: https://arcticwwf.org/work/ocean/arcnet/

ARCNET: AN ARCTIC OCEAN NETWORK OF PRIORITY AREAS FOR CONSERVATION

In 2021, WWF and partners launched ArcNet, a network of priority areas for marine conservation across the entire Arctic Ocean and adjacent seas. ArcNet reflects the web of marine life and ecological functions across a connected ocean that underpins the diverse values of people in the region and beyond.[424]

At the heart of the project is a purpose-built database of marine life that shows where more than 800 different features and functions of the Arctic's ecosystem can be found. Over four years, world-class experts specializing in Arctic species and ecosystems provided input on five different aspects of the project: marine mammals, seabirds, fish, sea ice biota and benthos (life found on the bottom of the ocean). The result of that cooperative effort is a proposed network based on comprehensive, rigorous scientific analysis using the best-available data.[424]

“PROTECTING BLUE CORRIDORS FOR WHALES WILL HELP PROTECT OUR OCEANS AND OURSELVES”

CHRIS JOHNSON, GLOBAL LEAD
WWF PROTECTING WHALES & DOLPHINS INITIATIVE

APPENDIX 1. SATELLITE TELEMETRY DATA

SPECIES	AREA	NUMBER OF TRACKS	CONTRIBUTORS	CITATION / SOURCE
Blue whales	Eastern North Pacific	189	Daniel Palacios (Oregon State University)	Mate, B. R., Lagerquist, B. A. & Calambokidis, J. Movements of North Pacific Blue Whales During the Feeding Season Off Southern California and Their Southern Fall Migration. Mar. Mamm. Sci. 15, 1246–1257 (1999). Bailey, H., Mate, B. R., Palacios, D. M., Irvine, L., Bograd, S. J. & Costa, D. P. Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. Endanger. Species Res. 10, 93–106 (2010). Irvine, L. M., Mate, B. R., Winsor, M. H., Palacios, D. M., Bograd, S. J., Costa, D. P. & Bailey, H. Spatial and temporal occurrence of blue whales off the U.S. West Coast, with implications for management. PLoS One 9, (2014). Mate, B.R. Palacios, D.M. Baker, C.S. Lagerquist, B.A. Irvine, L.M. Follett, T. Steel, D. Hayslip, C.E. Winsor, M.H. Baleen Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas Covering the Years 2014, 2015, 2016, and 2017. Final Report Prepared for Commander, U.S. Pacific Fleet. Submitted to Naval Facilities Engineering Command Pacific, Pearl Harbor, Hawaii under Contract No. N62470-15-8006-17F4016 issued to HDR, Inc., San Diego, California. (2018). Oregon State University, unpublished. Tagged in California, USA (2014-2017).
Blue whales	Chile	10	Publication supplement	Hucke-Gaete, R., Bedriñana-Romano, L., Viddi, F. A., Ruiz, J. E., Torres-Florez, J. P. & Zerbini, A. N. From Chilean Patagonia to Galapagos, Ecuador: Novel insights on blue whale migratory pathways along the Eastern South Pacific. PeerJ 2018, 1–22 (2018).
Blue whales	Chile	15	Publication supplement	Bedriñana-Romano, L., Hucke-Gaete, R., Viddi, F. A., Johnson, D., Zerbini, A. N., Morales, J., Mate, B. & Palacios, D. M. Defining priority areas for blue whale conservation and investigating overlap with vessel traffic in Chilean Patagonia, using a fast-fitting movement model. Sci. Rep. 11, 1–16 (2021).
Blue, fin, Sei whales	Azores - Central Atlantic	Blue = 13 Fin = 16 Sei = 11	Rui Preito, Monica De Silva	Silva, M. A., Prieto, R., Jonsen, I., Baumgartner, M. F. & Santos, R. S. North Atlantic blue and fin whales suspend their spring migration to forage in middle latitudes: building up energy reserves for the journey? PLoS One 8, e76507 (2013). Silva, M. A., Jonsen, I., Russell, D. J. F., Prieto, R., Thompson, D. & Baumgartner, M. F. Assessing performance of Bayesian state-space models fit to Argos satellite telemetry locations processed with Kalman filtering. PLoS One 9, e92277 (2014). Prieto, R., Silva, M. A. & Waring, G. T. Sei whale movements and behaviour in the North Atlantic inferred from satellite telemetry. Endanger. Species Res. (2014). at https://www.int-res.com/abstracts/esr/v26/n2/p103-113/
Bowhead whales	North Atlantic - Spitsbergen	16	Christian Lydersen (Norweigan Polar Institute)	Lydersen, C., Vacquié-Garcia, J., Heide-Jørgensen, M. P., Øien, N., Guinet, C. & Kovacs, K. M. Autumn movements of fin whales (Balaenoptera physalus) from Svalbard, Norway, revealed by satellite tracking. Sci. Rep. 10, 16966 (2020).
Fin whales	North Atlantic - Newfoundland	12	Steve Ferguson, Cory Matthews, Jack Lawson	Unpublished
Fin whales	Chile	6	Natalya Hernández	Sepúlveda, M., Pérez-Álvarez, M. J., Santos-Carvallo, M., Pavez, G., Olavarría, C., Moraga, R. & Zerbini, A. N. From whaling to whale watching: Identifying fin whale critical foraging habitats off the Chilean coast. Aquat. Conserv. 28, 821–829 (2018).
Fin whales	Mediterranean	6	Daniel Palacios (Oregon State University)	Cotté, C., Guinet, C., Taupier-Letage, I. & Mate, B. Scale-dependent habitat use by a large free-ranging predator, the Mediterranean fin whale. Deep Sea Res. Part I (2009). Cotté, C., d'Ovidio, F., Chaigneau, A., Lévy, M., Taupier-Letage, I., Mate, B. & Guinet, C. Scale-dependent interactions of Mediterranean whales with marine dynamics. Limnol. Oceanogr. 56, 219–232 (2011).
Fin whales	Mediterranean	9	Simone Panigada (Tethys Research Institute)	Panigada, S., Donovan, G. P., Druon, J. N., Lauriano, G., Pierantonio, N., Pirotta, E., Zanardelli, M., Zerbini, A. N. & Di Sciara, G. N. Satellite tagging of Mediterranean fin whales: Working towards the identification of critical habitats and the focussing of mitigation measures. Sci. Rep. 7, 1–12 (2017).
Fin whales	North Atlantic - Svalbard	25	Christian Lydersen (Norweigan Polar Institute)	Lydersen, C., Vacquié-Garcia, J., Heide-Jørgensen, M. P., Øien, N., Guinet, C. & Kovacs, K. M. Autumn movements of fin whales (Balaenoptera physalus) from Svalbard, Norway, revealed by satellite tracking. Sci. Rep. 10, 16966 (2020).
Humpback whales	North Atlantic - Newfoundland	13	Steve Ferguson, Cory Matthews, Jack Lawson	Unpublished
Humpback whales	Central North Pacific - Hawaii	49	Daniel Palacios (Oregon State University)	Mate, B. R., Gisiner, R. & Mobley, J. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Can. J. Zool. (1998). Mate, B., Mesecar, R. & Lagerquist, B. The evolution of satellite-monitored radio tags for large whales: One laboratory's experience. Deep Sea Res. Part 2 Top. Stud. Oceanogr. 54, 224–247 (2007).
Humpback whales	Eastern North Pacific - Mexico	16	Daniel Palacios (Oregon State University)	Lagerquist, B. A., Mate, B. R., Ortega-Ortiz, J. G., Winsor, M. & Urbán-Ramirez, J. Migratory movements and surfacing rates of humpback whales (Megaptera novaeangliae) satellite tagged at Socorro Island, Mexico. Mar. Mamm. Sci. 24, 815–830 (2008). Oregon State University, unpublished. Tagged in Baja California, Mexico, N=6. (1998).
Sperm whales	Baffin Bay - Davis Strait	3	Steve Ferguson, Kyle Lefort, Nigel Hussey	Unpublished
Sperm whales	Gulf of Mexico	18	Daniel Palacios (Oregon State University)	Irvine, L. M., Winsor, M. H., Follett, T. M., Mate, B. R. & Palacios, D. M. An at-sea assessment of Argos location accuracy for three species of large whales, and the effect of deep-diving behavior on location error. Animal Biotelemetry 8, 20 (2020).

SPECIES	AREA	NUMBER OF TRACKS	CONTRIBUTORS	CITATION / SOURCE
Humpback whales	Southeast Alaska	46	Daniel Palacios (Oregon State University)	Mate, B., Mesecar, R. & Lagerquist, B. The evolution of satellite-monitored radio tags for large whales: One laboratory's experience. Deep Sea Res. Part 2 Top. Stud. Oceanogr. 54, 224–247 (2007). Palacios, D.M., B.R. Mate, C.S. Baker, C.E. Hayslip, T.M. Follett, D. Steel, B.A. Lagerquist, L.M. Irvine, and M.H. Winsor. Tracking North Pacific Humpback Whales To Unravel Their Basin-Wide Movements. Final Technical Report. Prepared for Pacific Life Foundation. Marine Mammal Institute, Oregon State University. Newport, Oregon, USA. 30 June 2019. 58 pp. doi:10.5399/osu/1117. (2019). https://ir.library.oregonstate.edu/concern/technical_reports/z890s0924 Oregon State University, unpublished. Tagged in SE Alaska. Years: 1997, 2014, 2015
Humpback whales	Southeast Atlantic	15	Howard Rosenbaum (Wildlife Conservation Society), Daniel Palacios (Oregon State University)	Rosenbaum, H. C., Maxwell, S. M., Kershaw, F. & Mate, B. Long-Range Movement of Humpback Whales and Their Overlap with Anthropogenic Activity in the South Atlantic Ocean. Conserv. Biol. 28, 604–615 (2014). Tagged in Gabon. N = 13 individuals. N = 2 individuals from Reisinger et al (2021) below.
Humpback whales	Southern Ocean	378	Ryan Reisinger (University of Southampton) and collaborators	Reisinger RR, Friedlaender AS, Zerbini AN, Palacios DM, Andrews-Goff V, Dalla Rosa L, Double M, Findlay K, Garrigue C, How J, Jenner C, Jenner M-N, Mate B, Rosenbaum HC, Seakamela SM, and Constantine R. Combining regional habitat selection models for large-scale prediction: circumpolar habitat selection of Southern Ocean humpback whales. Remote Sensing (2021).
Humpback whales	Northern Indian Ocean	15	Andrew Wilson	Willson, A., Leslie, M., Baldwin, R., Cerchio, S., Childerhouse, S., Collins, T., Findlay, K., Genov, T., Godley, B. J., Al Harthi, S., Macdonald, D. W., Minton, G., Zerbini, A. & Witt, M. J. Update on satellite telemetry studies and first unoccupied aerial vehicle assisted health assessment studies of Arabian Sea humpback whales off the coast of Oman. Document presented to the Scientific Committee of the International Whaling Commission. Bled, Slovenia: International Whaling Commission. (2018).
Humpback whales	Madagascar - Southwest Indian Ocean	14 - le Ste Marie 11- Anakao	Salvatore Cerchio (African Aquatic Conservation Fund), Lauren Trudelle (Neurosciences Paris Saclay) and collaborators	Cerchio, S., Trudelle, L., Zerbini, A. N., Charrassin, J. B., Geyer, Y., Mayer, F. X., Andrianarivelo, N., Jung, J. L., Adam, O. & Rosenbaum, H. C. Satellite telemetry of humpback whales off Madagascar reveals insights on breeding behavior and long-range movements within the southwest Indian Ocean. Mar. Ecol. Prog. Ser. 562, 193–209 (2016). Trudelle, L., Cerchio, S., Zerbini, A. N., Geyer, Y., Mayer, F.-X., Jung, J.-L., Hervé, M. R., Pous, S., Sallée, J.-B., Rosenbaum, H. C., Adam, O. & Charrassin, J.-B. Influence of environmental parameters on movements and habitat utilization of humpback whales (Megaptera novaeangliae) in the Madagascar breeding ground. Royal Society Open Science 3, 160616 (2016).
Humpback whales	Southwest Indian Ocean	15	Violaine Dulau (Globice)	Dulau, V., Pinet, P., Geyer, Y., Fayan, J., Mongin, P., Cottarel, G., Zerbini, A. & Cerchio, S. Continuous movement behavior of humpback whales during the breeding season in the southwest Indian Ocean: on the road again! Mov Ecol 5, 11 (2017).
Pygmy blue whales	Indonesia - Western Australia - Victoria	25	Australia Antarctic Division Data Centre	Andrews-Goff, V., Double, M., Moller, L., Attard, C., Bilgmann, K., Jonsen, I. and Paton, D. Switching state space model for pygmy blue whale satellite tag derived locations, Ver. 1. Australian Antarctic Data Centre. https://doi.org/10.26179/5e671120e52b4 (2020). https://data.aad.gov.au/metadata/records/AAS_4101_pygmy_blue_whale_SSSM Andrews-Goff, V., Double, M. and Gales, N. Filtered Argos location data for pygmy blue whales 2009 and 2011, Ver. 1, Australian Antarctic Data Centre - doi:10.4225/15/5af3cbf350bf0, (2018). https://data.aad.gov.au/metadata/records/AAS_2941_blue_whale_Argos_sda_filter_tracks
Southern right whales	South Africa	21	Daniel Palacios (Oregon State University), Els Vermuelen (University of Pretoria)	Mate, B. R., Best, P. B., Lagerquist, B. A. & Winsor, M. H. Coastal, offshore, and migratory movements of South African right whales revealed by satellite telemetry. Mar. Mamm. Sci. 27, 455–476 (2011).
Southern right whales	New Zealand to Australia	16	Australia Antarctic Division Data Centre	Andrews-Goff, V., Double, M., Mckay, A., & Bailleul, F. Argos location data for southern right whales satellite tagged off New Zealand and South Australia, Ver. 1. Australian Antarctic Data Centre. (2021). https://doi.org/10.26179/5d37c13fe2ff4 https://data.aad.gov.au/metadata/records/AAS_2941_4101_SRW_tracks
Southern right whales	SW Atlantic	33	Alex Zerbini and partners	Zerbini, A.N., Rosenbaum, H., Mendez, M., Sucunza, F., Andriolo, A., Harris, G., Clapham, P.J., Sironi, M., Uhart, M. and Ajó, A. Tracking southern right whales through the Southwest Atlantic: an update on movements, migratory routes and feeding grounds. Paper SC/66b/BRG26 presented to the IWC Scientific Committee, Bled, Slovenia, 7-19 June 2016. 16pp. (2016). Zerbini, A.N., Ajo, A.F, Andriolo, A., Clapham, P.J., Crespo, E., Gonzalez, R., Harris, G., Mendez, M., Rosenbaum, H., Sironi, M., Sucunza, F., and Uhart, M. Satellite tracking of Southern right whales (Eubalaena australis) from Golfo San Matías, Rio Negro Province, Argentina. Paper SC/67B/CMP/17 presented to the IWC Scientific Committee, Bled, Slovenia, 23 April-6 May 2018. 10pp. (2018).

APPENDIX 2. ADDITIONAL WHALE MOVEMENT DATA

SPECIES	REGION	SOURCE
Bowhead whales	Eastern Canada - West Greenland	Ferguson, S. H., Dueck, L., Loseto, L. L. & Luque, S. P. Bowhead whale (Balaena mysticetus) seasonal selection of sea ice. Mar. Ecol. Prog. Ser. 411, 285–297 (2010).
Bowhead whales	Bering - Chukchi - Beaufort Seas	Smith, M. A., Goldman, M. S., Knight, E. J. & Warrenchuk, J. J. Ecological Atlas of the Bering, Chukchi, and Beaufort Seas: Melanie A. Smith, Max S. Goldman, Erika J. Knight, and Jon J. Warrenchuk. (Audubon Alaska, 2017).
Humpback whales	North Atlantic	Robbins, J. Gulf of Maine Humpback Whales - Centre for Coastal Studies. Movebank (2021). at <https://www.movebank.org/cms/webapp?gwt_fragment=page=studies,path=study540299766>
Humpback whales	North Atlantic	Rikardsen, A. Blanchet, M.A. Øien, N. Biuw, M. Broms, F. KLeivane, L. Whaletrack. UiT - The Arctic University of Norway (2022). at <https://en.uit.no/prosjekter/prosjekt?p_document_id=505966>
Humpback whales	Global	Fleming, A. & Jackson, J. Global review of humpback whales (Megaptera novaeangliae). NOAA Technical Memorandum NMFS. U.S. DEPARTMENT OF COMMERCE (2011). at <https://repository.library.noaa.gov/view/noaa/4489/noaa_4489_DS1.pdf>

APPENDIX 3. MARINE AND ENVIRONMENTAL DATA

DATA LAYERS DISPLAYED IN MAPS AND INFOGRAPHICS	SOURCE
Marine Protected Areas	UNEP-WCMC and IUCN. Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], November 2021, Cambridge, UK: UNEP-WCMC and IUCN (2021). Available at: www.protectedplanet.net. For CCAMLR MPA data layers, special thanks to Cassandra Brooks, University of Colorado, Boulder (USA).
IUCN Important Marine Mammal Areas (IMMAs)	IUCN Marine Mammal Protected Areas Task Force. Global Dataset of Important Marine Mammal Areas (IUCN-IMMA). February 2022. Made available under agreement on terms of use by the IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force (2022). Available at www.marinemammalhabitat.org/imma-eatlas
Key Biodiversity Areas (KBAs)	BirdLife International. World Database of Key Biodiversity Areas. Developed by the KBA Partnership: BirdLife International, International Union for the Conservation of Nature, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Re:wild, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, Wildlife Conservation Society and World Wildlife Fund. September 2021 version (2021). Available at http://keybiodiversityareas.org/kba-data/request
Other Effective Area-based Conservation Measures (OECMs	UNEP-WCMC and IUCN. Protected Planet: The World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], November 2021, Cambridge, UK: UNEP-WCMC and IUCN (2021). Available at: www.protectedplanet.net.
Country Borders, Land and Sea Areas	Available at https://www.naturalearthdata.com/
Country EEZs	Flanders Marine Institute. Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (2019). Downloaded from https://www.marineregions.org/. Last accessed 10 February 2021. https://doi.org/10.14284/386.
Climate Change Data	GISTEMP Team: GISS Surface Temperature Analysis (GISTEMP), version 4. NASA Goddard Institute for Space Studies (2021). Dataset accessed 2021-03-22 at data.giss.nasa.gov/gistemp/. Lenssen, N., G. Schmidt, J. Hansen, M. Menne, A. Persin, R. Ruedy, and D. Zyss. Improvements in the GISTEMP uncertainty model. J. Geophys. Res. Atmos., 124, no. 12, 6307-6326, doi:10.1029/2018JD029522 (2019).
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