SC/69A/E/06rev1

Sub-committees/working group name: E

State of the Cetacean Environment Report (SOCER) 2023 - final version

M. Stachowitsch, N.A. Rose and E.C.M. Parsons

State of the Cetacean Environment Report (SOCER) 2023

Editors: M. Stachowitsch[1], N.A. Rose[2] and E.C.M. Parsons[3]

INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 (IWC, 1998) and 1998-5 (IWC, 1999), directed the Scientific Committee to provide regular updates on environmental matters that affect cetaceans. Resolution 2000-7 (IWC, 2001) welcomed the concept of the State of the Cetacean Environment Report (SOCER) and requested the annual submission of this report to the Commission. The first full SOCER (Stachowitsch *et al*., 2003) was presented in 2003 and subsequent editions initiated and continued a cycle of focusing on the following regions: Atlantic Ocean, Pacific Ocean, Arctic and Antarctic Oceans, Indian Ocean, and Mediterranean and Black Seas. Each SOCER also includes a Global section addressing the newest information that applies generally to the cetacean environment. The 2023 SOCER features the **Indian Ocean**, summarising key papers and articles published from ca. 2021 through 2023 to date. This year's regional SOCER represents the fourth year of the current cycle, which will be combined in a second 5-year compendium (2020: Atlantic Ocean through 2024: Mediterranean and Black Seas; see first 5-year compendium at *https://iwc.int/socer-report*) to present to the Commissioners at IWC/70.

INDIAN OCEAN

General

Cetaceans Among the Indicator Species for Kuwait's Marine Biodiversity

The Persian (Arabian) Gulf is facing increasing and accumulative degradation of its natural resources, which 'when combined with the overlying impacts of climate change is leading to a marked decline in the health status of its marine ecosystem'. This status can be gauged using indicator species within many habitats. Among Gulf cetaceans, indicator species include the Indian Ocean humpback dolphin, the Indo-Pacific bottlenose dolphin and the finless porpoise. Delphinid populations in the Gulf are thought to have declined by ca. 70% between 1986 and 1999. Unfortunately, very few data are available on most populations and on the causes of mortality, although likely culprits are parasites, boat strikes (propeller injuries) and entanglement in fishing gear. The authors called for a targeted programme of ongoing monitoring, the development and implementation of marine management plans and support for the Regional Organisation for the Protection of the Marine Environment.

(SOURCE: Edmonds, N.J., Al-Zaidan, A.S., Al-Sabah, A.A., Le Quesne, W.J.F., Devlin, M.J., Davison, L. and Lyons, B.P. 2021. Kuwait's marine biodiversity: Qualitative assessment of indicator habitats and species. Mar. Pollut. Bull. 163: 111915, https://doi.org/10.1016/j.marpolbul.2021.111915)

Proposal for a Large-Scale, Cohesive Network of Marine Protected Areas in the Red Sea

The Red Sea is a marine biodiversity hotspot, with relatively high endemism and habitat for 13 cetacean species. Despite an early recommendation for 75 Marine Protected Areas (MPAs), this was reduced to 12 spread over six countries. Although the MPA area coverage has since increased substantially, most remain in the proposal stage, with little or no implementation, management or legal enforcement. The authors suggested organising a 'Red Sea Challenge', in which all nations 'collaborate to build a consolidated network of MPAs that would address transboundary issues by focusing on connectivity'. This would help conserve migratory routes and critical habitats of flagship species.

[1] Department of Functional and Evolutionary Ecology, Bio-Oceanography and Marine Biology Unit, University of Vienna, Austria and Department of Paleontology, University of Vienna, Austria

[2] Animal Welfare Institute, Washington, DC, USA

[3] Defenders of Wildlife, Washington, DC, USA

(SOURCE: Gajdzik, L., Green, A.L., Cochran, J.E.M., Hardenstine, R.S., Tanabe, L.K., Tanabe, K. and Berumen, M.L. 2021. Using species connectivity to achieve coordinated large-scale marine conservation efforts in the Red Sea. Mar. Pollut. Bull. 166: 112244, https://doi.org/10.1016/j.marpolbul.2021.112224)

BETTER MANAGEMENT NEEDED OF PERSIAN (ARABIAN) GULF ECOSYSTEM

Concerns have been expressed about the marine ecosystem of the Gulf, a critical marine ecosystem and cetacean habitat. The waters are among the warmest on the planet and temperatures are increasing. These temperatures are affecting the marine food web in the Gulf, especially at higher trophic levels. However, fisheries in the region have not been well managed, with poor planning and enforcement of regulations and unreliable fisheries data, resulting in declining catch rates and shifts in tropic levels, with fewer higher trophic level species and more lower trophic level species from a proportional perspective - an indication of overfishing at the higher trophic levels. Species in the Gulf are also threatened by oil pollution, which is steadily increasing and currently is 47 times higher than the world's average level. Increased efforts to scientifically monitor and manage the Gulf ecosystem are essential, especially given the likely impacts of climate change on this region.

(SOURCE: Mashjoor, S., Kamrani, E. and Aziz, R. 2022. Overfishing and warming put Persian Gulf at risk. Science 378: 365, https://doi.org/10.1126/science.adf0216)

THE INDIAN OCEAN HUMPBACK DOLPHIN AS AN INDICATOR OF OCEAN HEALTH

The Indian Ocean humpback dolphin can be considered a regional indicator and flagship species for ocean health due to its coastal, non-migratory lifestyle and its distribution throughout the Indian Ocean. Fewer than 500 animals remain in South African waters and face multiple, synergistic threats. Due to the difficulty of untangling these environmental threats (e.g. tourism, coastal development, chemical pollution, bycatch in shark nets) and the lengthy duration of time such an effort would take, the authors presented a SWOT analysis and argued for 1) financial support for the SouSA Consortium, 2) increased engagement with the government to declare this dolphin a priority species for conservation and 3) a shift to more action-focused conservation efforts, the first being a Conservation Management Plan.

(SOURCE: Plön, S., Atkins, S., Cockroft, V., Conry, D., Dines, S., Elwen, S., Gennari, E., Gopal, K., Gridley, T., Hörbst, S., James, B.S., Penry, G., Thornton, M., Vargas-Fonseca, A. and Vermeulen, E. 2021. Science alone won't do it! South Africa's endangered humpback dolphins Sousa plumbea *face complex conservation challenges. Front. Mar. Sci. 8, https://doi.org/10.3389/fmars.2021.642226)*

THE OCEAN HEALTH INDEX GIVES LOWER-THAN-AVERAGE VALUES TO INDIA AND SRI LANKA

The Ocean Health Index (OHI) is based on 10 'goals', with each goal evaluated according to current status, likely future status, trend, pressures and resilience. The score ranges from 0 to 100 (optimal value). OHI ranked India at 57 points, which is lower (poorer) than the global average of 69. That ranking is 207 out of 220 regions. Indonesia was given a score of 63 out of 100, Sri Lanka 61 and Bangladesh 71 (better than the global average). The scores for other Indian Ocean states, including Mozambique, Tanzania, Somalia, Yemen, Maldives, Madagascar, Red Sea and Persian (Arabian) Gulf states, as well as additional islands and territories, can be found under:

(SOURCE: https://oceanhealthindex.org)

Habitat degradation

General

POOR STATUS OF INDONESIAN COASTAL WATERS

An overview of pollutant studies between 1986 and 2021 on coastal waters in Indonesia, the world's largest archipelagic country and its sixth largest in population, found that nutrients, heavy metals, organic pollutants and plastic debris were the most-studied contaminants. Of these, 82% (nutrients), 54% (heavy metals) and 50% (organic pollutants) exceeded standard limits, pointing to poor water quality in this region. The excess nutrients, for example, are correlated with hypoxia, eutrophication and HABs. This confirms findings of the Asian Development Bank that this problem requires immediate attention. One of the authors' recommendations was to optimise the open public database provided by the Ministry of Environment and Forestry and other provided websites.

(SOURCE: Adyasari, D., Pratama, M.H., Teguh, N.A., Sabdaningsih, A., Kusumaningtyas, M.A. and Dimova, N.. 2021. Anthropogenic impact on Indonesian coastal water and ecosystems: Current status and future opportunities. Mar. Pollut. Bull. 171: 112689, https://doi.org/10.1016/j.marpolbul.2021.112689)

DESALINATION PLANTS IN PERSIAN (ARABIAN) GULF MAY SOON HAVE A REGIONAL-SCALE IMPACT

Desalination facilities have been crucial for the rapid economic development of countries bordering the Gulf (e.g. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates). Le Quesne *et al.* (2021) concluded that the expansion of business-as-usual desalination will create a regional-scale problem and compromise sustainable development. Beyond well-known effects such as entrainment of organisms, these plants discharge brine, chemicals and heat. The expected capacity of seawater desalination plants by 2050 will be 80 million m^3 per day. Combined with climate change, this will elevate coastal water temperatures by at least 3°C, and more than one-third of the total volume of water between 0 and 10m depth will pass through the plants each year. This will adversely affect biodiversity, fisheries and coastal communities, with a potential loss of some species and habitats. The authors called for a range of mitigating actions. Hosseini *et al*. (2021) emphasised that the Gulf is already one of the most adversely affected marine environments worldwide due to climate change, oil and gas activities and coastal anthropogenic disturbances. They stated that 'desalination activities are one of the major pollution drivers regionally and internationally'. Gulf states are a hotspot in this regard, responsible for nearly 50% of global desalination capacity.

(SOURCES: Le Quesne, W.J.F., Fernand, L., Ali, T.S., Andres, O., Antonpoulou, M,m Burt, J.A., Dougherty, W.W., Edson, P.J., El Kharraz, J., Glavan, J., Mamiit, R.J., Reid, K.D., Sajwani, A. and Sheahan, D. 2021. Is the development of desalination compatible with sustainable development of the Arabian Gulf? Mar. Pollut. Bull. 173: 112940, https://doi.org/10.1016/j.marpolbul.2021.112940; Hosseini, H., Saadaoui, I., Moheimani, N., Al Saidi, M., Al Jamali, F., Al Jabri, H. and Ben Hamadou, R. 2021. Marine health of the Arabian Gulf: Drivers of pollution and assessment approaches focusing on desalination activities. Mar. Pollut. Bull. 164: 112085, https://doi.org/10.1016/j.marpolbul.2021.112085)

MARITIME ACCIDENTS IN SRI LANKA

Sri Lanka is an important hub for international shipping. Two recent maritime accidents - MT New Diamond (2020) and MV X-Press (2021) (see also Perera *et al*., 2023, below) - have highlighted the risk for future maritime environmental disasters in the Sri Lankan jurisdiction of the Indian Ocean. The authors reported that Sri Lanka still has no adequate planning and regulation in this respect at the national policy level, and pointed to a lack of awareness, action plans for immediate remediation and legal knowledge to address international maritime laws. In the framework of integrated coastal zone management, they formulated such a national policy and contingency plan to augment maritime safety. Their proposal involved four hierarchical administrative levels (village, divisional, district and national) and outlined the main steps of the proposed framework.

(SOURCE: Ratnayake, A.S. and Perera, U.L.H.P. 2022. Coastal zone management in Sri Lanka: A lesson after recent naval accidents. Mar. Pollut. Bull. 182: 113994, https://doi.org/10.1016/j.marpolbul.2022.113994)

PROPOSED MARICULTURE THREATENS PERSIAN (ARABIAN) GULF ECOSYSTEMS

A proposal by the Iranian government to introduce large-scale mariculture (open-net fish pens; 200,000 tons of fish per year) is projected, within one year, to bathe local coral reefs with nutrient levels that will kill them and damage mangrove forests. The most significant pollution from commercial mariculture is eutrophication involving the input of nitrogen and phosphorus. Based on the estimated nitrogen input and a hydrodynamic circulation model, within a few years the entire Gulf is projected to be affected. The planned projects 'have the potential to damage the mangroves and kill every reef in the Persian Gulf in a very short period of time'.

(SOURCE: Risk, M.R., Haghshenas, A.A. and Arab, A.R. 2021. Cage aquaculture in the Persian Gulf: A cautionary tale for Iran and the world. Mar. Pollut. Bull. 166: 112079, https://doi.org/10.1016/j.marpolbul.2021.112079)

Fisheries Interactions

BYCATCH RATES FOR TUNA GILLNET FISHERIES IN THE INDIAN OCEAN

Data from 10 bycatch sampling programmes conducted from 1981 to 2016 for pelagic gillnet (driftnet) fisheries in the Indian Ocean bordering Australia, Sri Lanka, India and Pakistan were used to estimate bycatch rates for cetaceans across all Indian Ocean tuna gillnet fisheries. A total of 4.1 million small cetaceans were estimated to have been bycaught between 1950 and 2018, although the actual number is likely to be substantially higher, as many bycaught animals may not have been landed, many animals may have died in discarded 'ghost nets' and injured animals may have escaped from nets but later died. Between 2004 and 2006, an estimated 100,000 small cetaceans were bycaught. Numbers have declined by 15% subsequently, despite an increase in tuna gillnet fishing effort, suggesting cetacean stocks are declining in the Indian Ocean. The authors estimated that small cetacean abundance in the Indian Ocean may be a mere 13% of numbers before the advent of the tuna driftnet fishery. Ninety-six percent of tuna driftnet bycatch is the result of fisheries from the following countries (in order of bycatch levels): Iran, Indonesia, India, Sri Lanka, Pakistan, Oman, Yemen, United Arab Emirates and Tanzania. This level of cetacean bycatch is unsustainable.

(SOURCE: Anderson, R.C., Herrera, M., Ilangakoon, A.D., Koya, K.M., Moazzam, M., Mustika, P.L. and Sutaria, D.N. 2020. Cetacean bycatch in Indian Ocean tuna gillnet fisheries. Endang. Species Res. 41: 39-53, https://www.int-res.com/articles/esr2020/41/n041p039.pdf)

ABANDONED, LOST OR DISCARDED FISHING GEAR AROUND SINGAPORE

Abandoned, lost, or discarded fishing gear (ALDFG) is a class of marine debris with far-reaching negative ecological and socio-economic impacts. It is estimated to make up 10% of the 6.5 million tons of marine debris annually entering the oceans globally. This study, based on a literature review between 2000 and 2019, as well as a survey of 10 sites between September 2018 and March 2019, 'recovered' a total of more than 25,000 items of ALDFG, both whole and fragmented, on the shores around Singapore, Indonesia. Fishing lines and nets were the most common items. The hotspots were beaches, the intertidal, mangroves and sites with significant coastal modifications. A total of 1,052 trapped organisms of 124 species was reported, with fish comprising the highest percentage (ca. 75%). Entanglement in ALDFGs is an important issue for cetaceans. The authors called for incentivising stakeholders by providing safe and convenient gear disposal systems and potential punitive measures. Elsewhere, 'fishing for litter' programmes in which fishers engage by bringing plastic, including gear, captured in their nets back to port for proper disposal, have helped tackle this problem.

(SOURCE: Gajanur, A.R. and Jaafar, Z. 2022. Abandoned, lost, or discarded fishing gear at urban coastlines. Mar. Pollut. Bull. 173: 113341, https://doi.org/10.1016/j.marpolbul.2022.113341)

DOCUMENTING FISHERY-RELATED INJURIES TO CETACEANS CAUGHT IN BATHER PROTECTION NETS IN SOUTH AFRICA

An effort was made to identify net-marks and other external signs of fishery-related injuries based on dolphins incidentally caught in bather protection nets set to deter sharks along the southeast coast of South Africa. Only a small percentage of Indian Ocean humpback dolphins and Indo-Pacific bottlenose dolphins known to have been caught in nets present external signs of entanglement. Thirty-six percent of the dolphins caught in the protection nets showed fishery-related marks on their skin. Females were more likely to show such marks (58%) and most such animals were immature. The authors concluded that investigating only external injuries/net-marks on stranded animals may not be a reliable indicator of fishery entanglement rates and argued for additional (e.g. histopathological) examinations.

(SOURCE: Roussouw, N. Winter, S., Hofmeyr, G.J.G., Wohlsein, P. Siebert, U. and Plön, S. 2022. External indicators of fisheries interactions in known bycaught dolphins from bather protection nets along the KwaZuluNatal coastline, South Africa. J. cetacean Res. Manage. 23: 127-139, https://doi.org/10.47536/jcrm.v23i1.338)

Marine Debris

MISMANAGED PLASTICS WASTE IN MALAYSIA

Malaysia features one of the highest abundances of coastal debris among Southeast Asian countries and has been ranked eighth worldwide in mismanaged plastics waste. The dominant debris is plastic (86%) and land-based debris is the major source (82%). The authors emphasised, as do many other studies in the region, the role of the monsoon season in increasing the abundance of marine debris.

(SOURCE: Azman, M.A., Ramli, M.Z., Othman, S.F.C. and Shafiee, S.A. 2021. The distribution of marine debris along the Pahang coastline, Malaysia during the Southwest and Northeast Monsoons. Mar. Pollut. Bull. 170: 112630, https://doi.org/10.1016/j.marpolbul.2021.112630)

SEAFLOOR LITTER IN THE INDIAN OCEAN

In East Africa, litter collected from trawling gear showed an average of 51 items/km² (166 kg/km²), with the highest density from Tanzania and the highest weight from Mozambique. The corresponding values from the Bay of Bengal were 43 items/km² and 374 kg/km². Most records from the latter region came from Myanmar, which included the highest value (764 items and 5,598 kg/km²). Littering was lower in the Indian Ocean than in Atlantic Africa. The findings showed no clear relationship between offshore littering and land litter management or population size. Although the data were not from a dedicated seafloor litter mapping effort, the authors hoped this information would fill knowledge gaps and help to fulfil the goals of the UN Sustainable Development Solutions Network, especially target 14.1 ('by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution').

(SOURCE: Buhl-Mortensen, L., Houssa, R., Weerakoon, W.R.W.M.A.P., Kainge, P., Olsen, M.N., Faye, S., Wagne, M.M., Myo Thwe, S., Cudjoe Voado, G. and Grøsvik, B.E. 2022. Litter on the seafloor along the African coast and in the Bay of Bengal based on trawl bycatches from 2011 to 2020. Mar. Pollut. Bull. 184: 114094, https://doi.org/10.1016/j.marpolbul.2022.114094)

MARINE LITTER IN THE RED SEA

Sources of litter in the Red Sea, an 'inlet' of the Indian Ocean, include recreational activities, fishing and shipping. This influx has increased due to the improper disposal of personal protective equipment (PPE) associated with the COVID-19 pandemic. The densities of macro-litter items on beaches ranged from 0.12-0.4 items/m²; submerged or entangled litter was reported at densities of up to 6 items/m², dominated by plastics and fishing gear. The authors called for promoting deposit legislation for plastic containers, initiating fishing for litter schemes (for fishing gear) and implementing adequate port reception facilities in accordance with MARPOL. The cetacean fauna of the Red Sea, potentially exposed to marine debris, is composed of 16 species, including three baleen whales.

(SOURCE: Diem, A.,Tesfaldet, Y.T., Hocherman, T., Hoon, V. and Zijlemans, K. 2023. Marine litter in the Red Sea: status and policy implications. Mar. Pollut. Bull. 187: 114495, https://doi.org/10.1016/j.marpolbul.2022.114495)

POTENTIAL 'GARBAGE PATCH' IN SOUTHERN INDIAN OCEAN

Beyond the well-known 'garbage patches' associated with ocean gyres in the Pacific and Atlantic Oceans, there is evidence of such a marine debris accumulation in the southern Indian Ocean. A survey involved 216 hours of observation covering nearly 5,500km. More than 99% of litter items were plastics, mostly from packaging and fishing gear. Half the items were recorded southeast of Madagascar. The authors called for more research into this rarely investigated area, including combining efforts with ongoing long-term monitoring of bird and marine mammal species. These data should be fed into oceanographic models coupled with drifter analyses.

(SOURCE: Connan, M., Perold, V., Dilley, B.J., Barbraud, C., Cherel, Y. and Ryan, P.G. 2021. The Indian Ocean 'garbage patch': Empirical evidence from floating macro-litter. Mar. Pollut. Bull. 169: 112559, https://doi.org/10.1016/j.marpolbul.2021.112559)

COVID-Related Personal Protective Equipment a Marine Issue in India

Gunasekaran *et al.* (2022) recorded a total of nearly 500 items of personal protective equipment (PPE), almost exclusively masks, in a survey of six beaches in southeast India. This was 'a common type of litter on Indian beaches' and a 'grave and alarming problem'. India has a shoreline of ca. 7,500 km, of which 43% are sand beaches. The authors noted that 'nearly 1.56 billion face masks were estimated to enter the Ocean in 2020', with India generating over 47,000 tons of COVID-19-related biomedical waste between August 2020 and June 2021 alone. The authors attributed this pollution to a lack of awareness and negligence by the population, as well as mismanagement of municipal waste. This study confirmed the PPE threat to wildlife through entanglement, entrapment and ingestion, as also reported elsewhere. Chowdhury *et al*. (2021) estimated the contribution of mismanaged COVID-19-related masks in coastal regions of 46 countries worldwide to be 0.15 to 0.39 million tons within a year. The overall plastics waste generated from used masks was significantly higher in Asian countries (1.5 million tons) than in Europe (ca. 0.5 million tons).

(SOURCES: Gunasekaran, K., Mghili, B. and Saravanakumar, A. 2022. Personal protective equipment (PPE) pollution driven by the COVID-19 pandemic in coastal environment, Southeast Coast of India. Mar. Pollut. Bull. 180: 113769, https://doi.org/10.1016/j.marpolbul.2022.113769; Chowdhury H., Chowdhury, T. and Sait, S.M. 2021. Estimating marine plastic pollution from COVID-19 face masks in coastal regions. Mar. Pollut. Bull. 168: 112419, https://doi.org/10.1016/j.marpolbul.2021.112419)

Floating Plastic Debris in Indonesia

Large amounts of plastics waste discharged from rivers in Java and Bali pollute fishing areas in Indonesia and are driven toward the Indian Ocean (Iskanar *et al.*, 2022). Southern Java, Western Sumatra and the Bandan Sea were the most affected areas, with the northwest winter monsoon season playing a role in the discharges. The combined population of Java and Bali is 156 million, with most people living in coastal areas. The most effective way to reduce the debris would be to 'reduce mismanaged plastic over Yogyakarta, Banten and Bali provinces or along the Pogo River'. Cordova *et al*. (2022) examined 18 beaches in Indonesia. Due to Indonesia's rapid population expansion (400 million people in direct or indirect touch with Indian Ocean waters), the coastline is a hotspot for pollution, including marine debris. This has made 'the state of the coastline a critical issue at the junction of science and technology, governance, and community'. The average density was 2.7 items/m² and the average weight of debris was 166 g/m², with higher values during the rainy season. Based on three indices (Clean Coast Index [CCI], Hazardous Items Index, Beach Grade Index), however, the beaches were classified as 'moderately clean', with relatively few observed hazardous items, or 'good'.

(SOURCES: Iskandar, M.R., Cordova, M.R. and Park, Y.-G. 2022. Pathways and destinations of floating marine plastic debris from 10 major rivers in Java and Bali, Indonesia: A Lagrangian particle tracking perspective. Mar. Pollut. Bull. 185: 114331, https://doi.org/10.1016/j.marpolbul.2022.114331; Cordova, M.R., Iskandar, M.R., Muhtadi, A. Nurhasanah, Saville, R. and Riani, E. 2022. Spatio-temporal variation and seasonal dynamics of stranded beach anthropogenic debris on Indonesian beach [sic] *from the results of nationwide monitoring. Mar. Pollut. Bull. 182: 114035, https://doi.org/10.1016/j.marpolbul.2022.114035)*

Marine Litter Pollution in Bangladesh

Based on 10 sampling sites in the Bay of Bengal, marine litter density ranged from 0.14-0.58 items/m². Plastics dominated, although aluminium cans were the most abundant item. Fishing nets, clothing, footwear, food packs and sheeting were also among the dominant categories. The CCI indicated beaches here ranged from clean to dirty. The authors cited insufficient information on the confounding factors behind marine debris flows, such as winds, ocean currents and the monsoon cycle, and identified strategies to be implemented to document and ameliorate the problem. Several other papers on beach litter in Bangladesh have been published in recent issues of *Marine Pollution Bulletin*, indicating the predominance/importance of this form of pollution in the region. The authors considered marine litter to be a major threat to the marine ecosystem in Bangladesh.

(SOURCE: Islam, Md. S., Phoungthong, K., Islam, A. R. Md. T., Ali, M.M., Ismail, Z., Shahid, S. Kabir, Md. H. and Idris, A.M. 2022. Sources and management of marine litter pollution along the Bay of Bengal coast of Bangladesh. Mar. Pollut. Bull. 185: 114362, https://doi.org/10.1016/j.marpolbul.2022.114362)

High Microplastic Levels in Zanzibar, Tanzania

Nchimbi *et al.* (2022) note that microplastic pollution in the marine environment is perhaps one of the biggest environmental challenges in developing countries. This is due to lack of proper solid waste management, with countries with a minimal industrial base having recycling rates close to 0%. The authors cite increasing tourism and growing trade between China and Tanzania as contributing to the widespread microplastics here. Maione (2021) recorded litter on four tourist beaches on the island. Plastics made up half of the litter, with single-use packaging dominating at all sites. The author pointed to poor waste management and identified residential households, tourism, building and construction and the commercial sectors as contributors.

(SOURCES: Nchimbi, A.A., Shilla, D.A., Kosore, C.M., Shilla, D.J., Shashoua, Y. and Khan, F.R. 2022. Microplastics in marine beach and seabed sediments along the coasts of Dar es Salaam and Zanzibar in Tanzania. Mar. Pollut. Bull. 185: 114305, https://doi.org/10.1016/j.marpolbul.2022.114305; Maione, C. 2021. Quantifying plastics waste accumulations on coastal tourism sites in Zanzibar, Tanzania. Mar. Pollut. Bull. 168: 112418, https://doi.org/10.1016/j.marpolbul.2022.112418)

BEACH LITTER ALONG THE INDIAN COAST

The amount of marine debris/beach litter on beaches can serve as a proxy for the amount in the adjoining ocean. The density of beach litter in a national, Pan-India beach litter study of 33 beaches in 2019 and 30 beaches in 2021 yielded average values of 0.48 ± 0.5 and 0.3 ± 0.4 items/m² respectively. Based on the CCI, six of the 33 beaches in 2019, and three of the 30 beaches in 2021, were classified as 'extremely dirty'. Tourism and public littering of single-use plastics were the principal sources. The authors mentioned better solid waste management and stringent implementation of environmental legislation as amelioration strategies, and engaging with, and better education of, the public as crucial approaches.

(SOURCE: Mishra, P., Kaviarasan, T., Sambandam, M., Dhineka, K., Ramana Murthy M.V., Iyengar, G., Singh, J. and Andichandran, M. 2023. Assessment of national beach litter composition, sources, and management along the Indian coast - a citizen science approach. Mar. Pollut. Bull. 186: 114405, https://doi.org/10.1016/j.marpolbul.2022.114405)

MAJOR POLLUTION WITH PLASTIC NURDLES IN SRI LANKA

In May 2021, the cargo vessel MV X-Press Pearl, carrying hazardous chemicals, plastic nurdles, metals and bunker fuel, caught fire and sank off the coast of Sri Lanka. This was 'the largest marine debacle in the maritime history of Sri Lanka' and severely affected the marine environment in the Indian Ocean. Tons of plastic nurdles and remnants of burnt plastics spread over a large area, including the coastlines of Indonesia, Malaysia and Somalia. The discharge also contained a wide range of heavy metals. The authors stated that, one year after the incident, the degradation of the nurdles added a significant amount of microplastics to the Indian Ocean. Several other papers on the repercussions of this incident have been published in recent issues of *Marine Pollution Bulletin*.

(SOURCE: Perera, U.L.H.P., Subasinghe, H.C.S., Sandaruwan Ratnayake, A., Weerasingha, W.A.D.B. and Wijewardhana, T.D.U. 2022. Maritime pollution in the Indian Ocean after the MV X-Press Pearl accident. Mar. Pollut. Bull. 185: 114301, https://doi.org/10.1016/j.marpolbul.2022.114301)

THE STATUS OF PLASTICS POLLUTION IN THE INDIAN OCEAN

The plastics problem is of particular concern in the Indian Ocean because Asia currently produces the world's highest share of mismanaged plastics waste. India has one of the fastest developing plastics industries (15 large-scale polymer manufacturers, 30,000 plastic processing plants). The country generated 3.36 million tons of plastics waste in 2017-2018, with coastal regions contributing 62% of this total waste. Plastic consumption has grown 20-fold in the last three decades and the current per capita consumption is an estimated 22kg per year. The ecological risk is expected to increase due to unsustainable production and consumption patterns. Extreme weather events (heavy rainfall, cyclones and associated flooding) have become a major pollution-relevant concern in the Indian subcontinent and further multiply the plastics waste generated. The Ganges-Brahmaputra River, flowing mainly through India, is the sixth highest plastics waste contributor to the Indian Ocean, although smaller rivers are the major contributors. Indian rivers are the second highest plastics polluters to the ocean. The authors highlighted a wide range of actions encompassing all levels of society as being necessary to tackle this issue.

(SOURCE: Sivadas, S.K., Mishra, P., Kaviarasan, T., Sambandam, M., Dhineka, K., Ramana Murthy, M.V., Nayak, S., Sivyer, D. and Hoehn, D. 2022. Litter and plastic monitoring in the Indian marine environment: A review of current research, policies, waste management, and a roadmap for multidisciplinary action. Mar. Pollut. Bull. 176: 113424, https://doi.org/10.1016/j.marpolbul.2022.113424)

Ship Strikes

SHIPPING ROUTES OFF SRI LANKA CHANGED TO PROTECT CETACEANS

In light of IWC deliberations, the non-governmental organisations OceanCare and the International Fund for Animal Welfare negotiated with the Mediterranean Shipping Company and Stolt-Nielsen (the world's largest chemical tanker company) to shift the companies' shipping routes 15 nautical miles south of Sri Lanka to avoid a blue whale hotspot. The Verband Deutscher Reeder/German Shipowners' Association and the International Chamber of Shipping have recommended that their members follow this example. This is an important step forward in reducing a main threat (ship strikes) to an important population of endangered blue whales.

(SOURCES: https://www.oceancare.org/en/stories_and_news/shipping-and-whales/; https://www.ifaw.org/de/press-releases/blauwal-schutz-msc)

Chemical Pollution

POTENTIALLY TOXIC ELEMENTS IN THE PERSIAN (ARABIAN) GULF

A range of potentially toxic elements - As, Cd, Co, Cr, Cu, Hg, Pb, Se and Zn - were examined in five species utilised as seafood, revealing high levels in the muscle tissues. A crab and a predatory fish had the highest values. The cancer risk from As for seafood consumers was higher than the acceptable lifetime risk. The concentrations of some elements were very low, but the mean Pb concentration in all studied species exceeded the international maximum permissible level. The authors found 'that there is a potential health risk from consumption of marine species from Persian Gulf [sic] for local consumers'. These results are important because 1) the Gulf is a semi-enclosed system with an average depth of only 35-40m and long 'flushing' times and 2) the muscle values of contaminants (as examined here) are typically lower than those of certain internal organs, indicating a higher level of threat to the organisms themselves, especially those higher up the food chain, such as cetaceans.

(SOURCE: Ahmadi, A., Moore, F., Keshavarzi, B., Soltani, N. and Soroosgian, A. 2022. Potentially toxic elements and microplastics in muscle tissues of different marine species from the Persian Gulf: Levels associated risks, and trophic transfer. Mar. Pollut. Bull. 175: 113283, https://doi.org/10.1016/j.marpolbul.2022.113283)

ENDOCRINE DISRUPTING CHEMICALS POSE A POTENTIAL THREAT IN THE PERSIAN (ARABIAN) GULF

The levels of endocrine disrupting chemicals (EDCs) in two widely consumed fish species in the Gulf suggest a prolonged exposure to these pollutants. EDCs can bioaccumulate in fish tissues and biomagnify along the food chain. The values off Iran were 'many times greater' than in seafood from other regions. The authors attributed this to a rapidly increasing population (50 to 150 million in the past 50 years, expected to increase to 200 million by 2030), as well as to domestic sewage, industrial discharges, effluent of desalination plants, plastics waste, oil-related activities and regional political conflicts (e.g. the 1980 Iran-Iraq war, the 1991 Gulf war). Based on international guidelines, a risk assessment for humans revealed a moderate risk to consumers.

(SOURCE: Akhbarizadeh, R., Russo, G., Rossi, S., Golianova, K., Moore, F., Guida, M., De Falco, M. and Grumetto, L. 2021. Emerging endocrine disruptors in two edible fish from the Persian Gulf: Occurrence, congener profile, and human health risk assessment. Mar. Pollut. Bull. 166: 112241, https://doi.org/10.1016/j.marpolbul.2021.112241)

TOXIC SUBSTANCES RELEASED AT SHIP BREAKING SITES IN THE BAY OF BENGAL, BANGLADESH

Ali *et al.* (2022) studied the concentrations of four toxic metals (As, Cr, Cd and Pb) at a site where ships are dismantled for scrap recycling (known as ship breaking). Such operations, which drive ships directly onto the shoreline, have long been known to have a negative environmental impact. Toxic metals, petroleum hydrocarbons, perfluoroalkyl acids and bacterial contaminants are among the pollutants released by this industry. The concentrations of heavy metals in the sediment and water exhibited a critical score based on the Metal Pollution Index. The Potential Ecological Risk Index suggested 'that the study area was at high risk due to metals pollution' and 'the metal concentrations surpassed the environmental safe limit', having 'a considerable negative impact on natural productivity of the coastal ecosystem'. In Bangladesh, the ship breaking industry has been expanding, even though most yards now operate in South Asian countries (lower labour costs, less stringent environmental regulations). The authors stated that 'a longer stretch along the seashore is in no way justifiable for the continuance of this enterprise' and argued for selecting a separate zone for the activity, such as a dockyard. Kakar *et al*. (2021) examined this issue in Pakistan. The Gadani ship breaking yard is the world's third largest. The concentration of Hg on the beach in this zone was 50 times higher than in a reference area. The authors also made a connection with predicted sea-level rise, determining that large amounts of polluted sand could be washed out from the beaches here, which would potentially worsen Hg contamination in the coastal ecosystem, at least on a local level.

(SOURCES: Ali, M.M., Islam, Md.S., Islam, A.R.Md.T., Bhuyan, Md.S., Ahmed, A.S.S., Rahman, Md.Z. and Rahman, Md.M. 2022. Toxic metal pollution and ecological risk assessment in water and sediment at ship breaking sites in the Bay of Bengal Coast, Bangladesh. Mar. Pollut. Bull. 175: 113274, https://doi.org/10.1016/j.marpolbul.2022.113274; Kakar, A., Liem-Nguyen, V., Mahmood, Q. and Jonsson, S. 2021. Elevated concentrations of mercury and methylmercury in the Gadani shipbreaking area, Pakistan. Mar. Pollut. Bull. 165: 112049, https://doi.org/10.1016/j.marpolbul.2022.112049)

MERCURY CONCENTRATIONS IN SOUTH AFRICAN SHARKS, SKATES AND RAYS

South Africa is one of the top 10 contributors to mercury emissions globally. On the east coast (Indian Ocean) side of South Africa, Hg concentrations ranged between 0.21 and 17.8 mg/kg in shortfin devil rays and scalloped hammerhead sharks. These values were in the same range or higher than in the same species sampled ca. 10 years earlier (2005-2010) and higher compared to the same species sampled globally. This points to an ongoing or increasing exposure risk. Hg is a priority element in pollutant monitoring because, as a heavy metal, it is subject to bioaccumulation in predators at the end of the food chain (such as cetaceans) and poses a threat to humans consuming seafood.

(SOURCE: Erasmus, J.H., Smit, N.J., Gerber, R., Schaeffner, B.C., Nkabi, N. and Wepener, V. 2022. Total mercury concentrations in sharks, skates and rays along the South African Coast. Mar. Pollut. Bull. 184: 114142, https://doi.org/10.1016/j.marpolbul.2022.114142)

HEAVY METALS AND FLAME RETARDANTS IN SOUTHWEST INDIAN OCEAN DOLPHINS

Apex predators such as dolphins can be valuable indicators of ocean health. Plön *et al.* (2023) investigated 36 elements in three species of dolphin in the Indian Ocean: the Indian Ocean humpback dolphin, the Indo-Pacific bottlenose dolphin and the common dolphin. They confirmed the high organic pollutant concentrations previously reported for these species here. Hg concentrations, for example, were generally higher than those reported for coastal dolphins elsewhere. The authors attributed these differences to differences in habitat, feeding ecology, age and possibly species physiology and exposure to pollutant levels. The lack of data on many of these aspects highlights the difficulty of determining risk and identifying the origin of such compounds, calling for more detailed studies and for the need to reduce pollutant sources. Aznar-Alemany *et al*. (2019) examined a wide range of flame retardants (PBDEs) in the same three species. The mean PBDE concentration was 416 ± 333 ng g^{-1} lw. The levels were 'as high as in more industrialized areas, such as Europe'. Further studies are required to determine whether these levels reflect local contamination or are more widespread in the Indian Ocean and whether these compounds contribute to population declines.

(SOURCE: Plön, S., Roussouw, N., Uren, R., Naidoo, K., Siebert, U., Cliff, G. and Bouwman, H. 2023. Elements in muscle tissue of three dolphin species from the east coast of South Africa. Mar. Pollut. Bull. 188: 114707, https://doi.org/10.1016/j.marpolbul.2022.114707; Aznar-Alemany, O., Sala, B., Plön, S., Bouwman, H., Barcelo, D. and Eljarra, E. 2019. Halogenated and organophosphorus flame retardants in cetaceans from the southwestern Indian Ocean. Chemosphere 226: 791-799, https://doi.org/10.1016/j.chemosphere.2019.03.165)

HEAVY METAL POLLUTION ALONG THE COAST OF SOUTHERN INDIA

Vinothkannan *et al.* (2022) measured the concentrations of four heavy metals in 12 fish species consumed by humans along the Bay of Bengal, Tamil Nadu, revealing values for Cu and Zn that were higher than the global data, with Cd and Pb also higher for a few species. Overall, the Cd levels were lower than global statistics, but still higher than international regulatory limits (see FAO/WHO). The hazard indices were 'on the verge of exceeding the safe limits for consumption of these fish' and the authors predicted that, in the near future, these index values would exceed the safe consumption limits. Based on the biomagnification of heavy metals along the food chain, long-lived marine organisms at the top of that chain, such as cetaceans, have the highest values. Rubalingeswari *et al*. (2021) reported that, due to bioaccumulation, the concentrations of Cu, Cr and Fe in fishes were 14, 2 to 3, and 15 times higher than WHO standards, respectively, along the southeast coast of India (off the metropolis of Chennai).

(SOURCE: Vinothkannan, A., Rajaram, T.R., Charles, P.E. and Ganeshkumar, A. 2022. Metal-associated human health risk assessment due to consumption of pelagic and benthic ichthyofaunal resources from the highly contaminated Cuddalore coast in Southern India. Mar. Pollut. Bull. 176: 113456, https://doi.org/10.1016/j.marpolbul.2022.113456; Rubalingeswari, N., Thulasimala, D., Giridharan, L., Gopal, V., Magesh, N.S. and Jayaprakash, M. 2021. Bioaccumulation of heavy metals in water, sediment, and tissues of major fisheries from Adyar estuary, southeast coast pf India: An ecotoxicological impact of a metropolitan city. Mar. Pollut. Bull. 163: 111964, https://doi.org/10.1016/j.marpolbul.2020.111964)

Disease and mortality events

Disease

SEWAGE POLLUTION IN SOUTHERNMOST INDIA

Samples collected from a sewage discharge point along the eastern shore of Kanyakumari yielded nine pollution indicator bacteria and pathogenic species. All the isolates were resistant to at least two antibiotics, and such antibiotic-resistant bacteria have been used as bioindicators of pollution. The domestic sewage released here is clearly untreated, threatening coastal water quality and the health of humans and marine ecosystems. The authors concluded that 'the fecal contamination has made the shore unfit for fishing activities'. Globally, sewage is a major component of coastal pollution from land-based activities, which account for about three-fourths of all pollutants entering the world's oceans.

(SOURCE: Victoria, N.S., Kumaria, T.S.D. and Lazarus, B. 2022. Assessment of impact of sewage in coastal pollution and distribution of fecal pathogenic bacteria with reference to antibiotic resistance in the coastal area of Cape Comorin, India. Mar. Pollut. Bull. 175: 113123, https://doi.org/10.1016/j.marpolbul.2022.113123)

Harmful Algal Blooms (HABs)

HYPOXIA IDENTIFIED AS A POTENTIAL PROBLEM IN PERSIAN (ARABIAN) GULF

The Gulf measures about 240,000km² with a mean depth of 36m. It has a considerable area suffering from low levels of oxygen: 20 monitoring stations (90%) had low oxygen waters in summer, with even lower levels (hypoxia) detected in three of these stations. In autumn the corresponding values were 13 and 11 stations, respectively. The authors attributed this to domestic effluents that, although receiving secondary treatment, still 'contain high-suspended solids and high levels of nutrients'. This represents eutrophication of these waters and has been implicated in increasing frequency of HABs. Hypoxia, as a symptom of eutrophication, can cause behavioural modifications and first mortalities of benthic organisms and avoidance reactions by larger mobile marine fauna. The authors stated that the impacts of hypoxia and decline in seawater pH may have synergistic effects on Gulf biota, arising from warming and eutrophication, and called for regular monitoring. Moreover, the oxygen-poor water leaving the Gulf and entering the Gulf of Oman may expand the oxygen minimum zone there.

(SOURCE: Saleh, A., Abtahi, B., Mirzaei, N., Chen, C.-T., A., Ershadifar, H., Ghaemi, M. Hamzehpour, A. and Abedi, E. 2021. Hypoxia in the Persian Gulf and the Strait of Hormuz. Mar. Pollut. Bull. 167: 112354, https://doi.org/10.1016/j.marpolbul.2021.112354)

Oil Spills

WORST OIL SPILL IN MAURITIUS HISTORY

On 25 July 2020, the 300m-long bulk carrier Wakashio ran aground on a coral reef on the southeast coast of Mauritius. It began to leak oil on 6 August and broke in two on 15 August. The bow section was towed to the open ocean and scuttled on 24 August. It was carrying nearly 4000 tons of fuel, 200 tons of diesel and 90 tons of lubricant oil (from China to Brazil). '[T]his spill was likely the worst environmental incident in the history of Mauritius, with effect possibly lingering for decades'. The spill damaged the island's food system and degraded the coast for tourism. More than 100 whales and dolphins washed up dead after the spill. The authors underlined the length of time between the grounding and final scuttling, and emphasised that 'no major action has been taken to protect the island's waters from similar future incidents'.

(SOURCE: Rajendran, S., Aboobacker, V.M., Seegobin, V.O., Al Khayat, J.A., Rangel-Buitrago, N., Al-Kuwari, H.A.-S., Sadooni, F.N. and Vethamony, P. 2022. History of a disaster: A baseline assessment of the Wakashio oil spill on the coast of Mauritius, Indian Ocean. Mar. Pollut. Bull. 175: 113330, https://doi.org/10.1016/j.marpolbul.2022.113330)

Climate change

MARINE HEATWAVES INCREASING IN THE PERSIAN (ARABIAN) GULF AND OMAN SEA

Marine Heatwaves (MHWs) are defined as separate episodes of prolonged, unusual sea surface temperature increases lasting at least five days. The spatial extent of MHWs in the Gulf and Oman Sea has doubled in the last 24 years. The number of episodes has increased by about three times, and the average number of days in the central Gulf has increased about 19 times compared to 1982-1997. The Gulf is one of the warmest of the globe, and temperature increases in already warm seas represent a particular threat to marine organisms, many of which are already living at the peak of their temperature tolerances. Note also that the Gulf holds about two-thirds of the world's oil reserves and one-third of its natural gas reserves, posing an ongoing potential threat to the state of this water body and its many ecosystems.

(SOURCE: Beyraghdar Kashkooli, O., Karimian, S. and Modarres, R. 2022. Spatiotemporal variability of the Persian Gulf and Oman Sea marine heatwaves during 1982-2020. Mar. Pollut. Bull. 184: 114174, https://doi.org/10.1016/j.marpolbul.2022.114174)

Noise impacts

NOISE AND CETACEANS IN LIGHT OF LARGE-SCALE DEVELOPMENT IN THE INDIAN OCEAN

Plön and Roussouw (2022) reported on plans for large-scale economic developments in the Indian Ocean, including increased shipping, oil and gas exploration and offshore mining. These plans have resulted in concerns about potential impacts on cetaceans. The available literature for two focal species - the Indian Ocean humpback dolphin and the humpback whale - highlighted an absence of baselines upon which to measure future impacts from anthropogenic developments in this region. The authors suggested an integrated approach of combining studies on live (e.g. AEPs in odontocetes, recordings of vocalisations and behavioural observations) and dead, stranded animals (e.g. ear anatomy in odontocetes and mysticetes). This work could support larger continental discussions on sustainable development in the African Union's Agenda 2063 (38 out of the 54 African States are coastal). Similar ocean economy developments are currently underway worldwide. Schoeman *et al*. (2022) examined the soundscape in two bays in South Africa in light of economic plans in which port development will play an important role. Biological and wind sounds dominated, but ship noise was present at all sites. Shipping, however, is expected to increase here and is likely a significant noise source in shallow waters along the South African coast where vessel density is known to be higher.

(SOURCE: Plön, S. and Roussouw, N. 2022. Focusing on the receiver - Hearing in two focal cetaceans exposed to Ocean Economy developments. Appl. Acoust. 196: 108890, https://doi.org/10.1016/j.apacoust.2022.108890; Schoeman, R.P., Erbe, C. and Plön, S. 2022. Underwater chatter for the win: A first assessment of underwater soundscapes in two bays along the Eastern Cape Coast of South Africa. J. Mar. Sci. Eng. 10: 746, https://doi.org/10.3390/jmse10060746)

GLOBAL

General

OCEAN LITERACY - A CORNERSTONE IN INFLUENCING ATTITUDES AND DRIVING CHANGE?

The concept of ocean literacy, first introduced in the early 2000s, mirrors a spectrum of new terms and concepts that have been introduced in the recent past to describe principles of ecology and conservation relevant to our perception of the environment and the need to take action. This contribution uses supporting concepts such as marine citizenship, ocean connectedness and public perception research to propose ten dimensions in the evolving definition and understanding of ocean literacy: knowledge, communication, behaviour, awareness, attitudes, activism, emotional connection, access and experience, adaptive capacity and trust and transparency. This would enable the concept to encompass diverse knowledge, values and experiences. That framework, in turn, would help the concept in its role of delivering international ocean commitments. This issue has become a cornerstone for the United Nations Ocean Decade and is directly relevant to the workings of the International Whaling Commission.

(SOURCE: McKinley, E., Burdon, D. and Shellock, R.I. 2023. The evolution of ocean literacy: A new framework for the United Nations Ocean decade and beyond. Mar. Pollut. Bull. 186: 114467, https://doi.org/10.1016/j.marpolbul.2022.114467)

NEW KRILL COMMITTEE FOR BETTER SCIENTIFIC MANAGEMENT OF THIS ESSENTIAL CETACEAN FOOD SOURCE

With a biomass of 300 to 500 million tonnes, krill are one of the most abundant species on the planet. They are also a keystone species for the Antarctic marine environment and the main food source for multiple whale species. Krill also play an important role in marine biogeochemical cycles that affect climate and ocean productivity. However, krill have been declining since the 1920s, especially in the Atlantic region adjacent to the Southern Ocean. Since 2010, industrial krill fishing has been increasing and is likely to expand further. With new technologies, the krill are a being caught more efficiently and effectively. Krill is harvested for fishmeal for the aquaculture industry, and for krill oil for the pharmaceutical industry. Climate change may also be negatively affecting krill stocks and reducing their productivity, recruitment and abundance. To address issues related to krill and the potential impacts on their Antarctic predators, such as cetaceans, a krill expert group was established under the Scientific Committee on Antarctic Research to provide management recommendations to CCAMLR. This information will also be of interest to the IWC Scientific Committee.

(SOURCE: Meyer, B. and Kawaguchi, S. 2022. Antarctic marine life under pressure. Science 378: 230, https://www.science.org/doi/full/10.1126/science.adf3606)

NEW BIODIVERSITY CONSERVATION GOALS AND COMMITMENTS

In December 2022, the new Kunming-Montréal Global Biodiversity Framework (GBF) of the Convention on Biological Diversity (CBD) was established. The GBF aims to protect 30% of all lands and oceans globally (currently 10% of the oceans are under some degree of protection). The GBF set up a fund of US$30 billion per year - more than 10 times the aggregate protected area budgets for all parks agencies in developing countries worldwide - to fund protected area establishment and enforcement. The GBF also sets major goals to be achieved by 2050, including ensuring the integrity of ecosystems to prevent extinctions and conserve genetic diversity, the sustainable use of natural resources and sufficient funding and technical expertise to achieve the aims of the GBF. The framework also asks governments to meet several targets by 2030, including expanding protected areas, cutting nutrient pollution in half, reducing the risk from pesticides by 90% and restoring or initiating restoration of at least 30% of degraded terrestrial, inland waters and coastal and marine ecosystems. Nations are also called on to eliminate US$500 billion in environmentally harmful subsidies, such as subsidising fuel for long-distance fishing fleets. The GBF explicitly recognises the role of indigenous peoples and local communities in protecting biodiversity. However, governments have failed to reach any of the previous goals set by the CBD and there is widespread scepticism regarding achievement of these new goals.

(SOURCE: Stokstad, E. 2022. New biodiversity pact sets ambitious targets, but will nations deliver? Science, https://doi.org/10.1126/science.adg4247)

NEW TREATY SETS UP A FRAMEWORK FOR HIGH SEAS MPAS

The high seas encompass the 60% of ocean area outside national waters. The United Nations Convention on the Law of the Sea does not provide a protection mechanism for these waters, and as a result only 1% of this area is highly protected (in the Ross Sea, Southern Ocean). On 4 March 2023, an international treaty addressing the high seas set up a legal framework by which high seas areas could be protected. Once ratified, to establish a high seas MPA would require a three-quarters majority vote by member nations. The treaty also provides a mechanism to help strengthen the research capacity of lower income nations.

(SOURCE: Stokstad, E. 2023. Nations agree on long-sought high seas biodiversity treaty. Science 379: 971, https://www.science.org/doi/pdf/10.1126/science.adh4964)

Habitat degradation

General

DECLINING IRON LEVELS THREATENS SOUTHERN OCEAN ECOSYSTEM PRODUCTIVITY

Phytoplankton blooms in the waters of the Southern Ocean form the base of the Antarctic food chain, feeding krill, which then feed marine mammals. However, phytoplankton in the Southern Ocean are at risk because of decreasing levels of the essential nutrient Fe. Analysing light emitted by phytoplankton has indicated that their Fe levels have decreased over the past two decades. In tandem with this decline, there has been a statistically significant decline in phytoplankton productivity. These Fe declines may be due to ocean acidification (a climate change effect), making it harder for phytoplankton to absorb Fe. Increasing ocean temperatures may also be increasing phytoplankton metabolic rates, which would increase the rate at which they utilise Fe. In addition, changes in ocean circulation may be reducing the transport of Fe-rich water from the deep ocean to the surface. (But see Levin *et al*. (2023) under **GLOBAL** for misgivings about schemes to artificially increase Fe in the oceans.) A change in phytoplankton levels could have a massive impact on Southern Ocean ecosystems, including cetaceans.

(SOURCE: Ryan-Keogh, T. 2023. Multidecadal trend of increasing iron stress in Southern Ocean phytoplankton. Science 379: 834-840, https://doi.org/10.1126/science.abl5237)

High Level Of Mining In Tropical Rivers

A satellite survey over 40 years has shown that river mining has affected 173 large rivers in 49 countries over the past 20 years and continues to do so. After mining started, levels of suspended sediment have doubled in 80% of these rivers. Nearly 7% of all large tropical river systems are now dealing with mining debris. This survey began due to concerns over Hg pollution from gold mining in rivers systems - gold mining is now the world's top source of Hg pollution, emitting more than coal-fired power stations. However, the mud and sediment produced by mining could also affect marine species. This study has implications for the contamination of riverine, estuarine and coastal habitats in the tropics and the cetaceans that inhabit them.

(SOURCES: Voosen, P. 2023. Surge in illegal river mining revealed in global survey. Science 379: 124-125, https://www.science.org/doi/pdf/10.1126/science.adg6274; Dethier, E., Silman, M., Leiva, J.D., Alqahtani, S., Fernandez, L., Pauca, P., Çamalan, S., Magilligan, F., Renshaw, C. and Lutz, D. 2022. The global crisis of mining in tropical rivers. Research Square (preprint). https://doi.org/10.21203/rs.3.rs-1875606/v1)

Marine Debris

The Global Plastic Ingestion Initiative

The Global Plastic Ingestion Initiative (GLOVE) is a new online and open-access database currently comprising 530 studies on plastic ingestion by various organisms. It includes almost 250,000 records encompassing nearly 1,500 species, many of them marine. The authors considered this a tool for designing effective actions in light of upcoming local and global agreements on plastics pollution. This is also a step toward reducing the science-policy gap by making the information contained in the scientific literature available to a broader public. The database is available under: https://gloveinitiative.shinyapps.io/Glove/.

(SOURCE: Moneiro, R., Andrades, R., Noleto-Filho, E., Pegado, T., Morais, L., Goncalves, M., Santos, R., Sbrana, A., Franceschini, Soares, M.O., Russo, T. and Giarrizzo, T. 2022. GLOVE: The Global Plastic Ingestion Initiative for a cleaner world. Mar. Pollut. Bull. 185: 114244, https://doi.org/10.1016/j.marpolbul.2022.114244)

Global Plastics Treaty Needs to Address Ghost Fishing Gear

On 2 March 2022, 175 nations agreed to negotiate a UN plastics treaty to fight plastics waste globally. Negotiators will meet to develop the details of the treaty and their goal is to have the legally-binding agreement finalised by 2024. An international treaty is needed to address ghost fishing gear, a major source of ocean plastic. These abandoned or lost nets, typically made of synthetic materials that do not biodegrade or do so very slowly, entangle and kill marine mammals and other species. Considering the demand to feed a growing global population, fishing effort is likely to increase, increasing ghost gear in the oceans. A plastics treaty should establish monitoring programmes for ghost gear; mandate limiting the sale of nylon nets; replace synthetic fishing gear with biodegradable alternatives (which already exist); set up schemes to remove ghost gear; and conduct outreach, education and training.

(SOURCE: Vitorino, H., Ferrazi, R., Correia-Silva, G., Tinti, F., Belizário, A.C., Amaral, F.A., Ottoni, F.P., Silva, C.V., Giarrizzo, T., Arcifa, M.S. and Azevedo-Santos, V.M. 2022. New treaty must address ghost fishing gear. Science 376: 1169. 10.1126/science.adc9254, https://www.science.org/doi/10.1126/science.adc9254)

Microplastics – The Emerging Issue in the Marine Environment

Plastics in the ocean have become a hot topic in marine pollution, with one editor of the foremost journal in this field, *Marine Pollution Bulletin*, jokingly referring to it as *Marine Plastic Pollution Bulletin*. The research has evolved from larger marine debris to microplastics and even smaller nanoplastics. An examination of 3,344 research papers on microplastics published in the period 2004-2020 showed a rapid development in the number of articles, with nearly 70% having been published in the past three years. American, British and Chinese researchers contributed the most. The focus is currently on ecological risks, interrelationships between microplastics and other pollutants and detection methodology. Although microplastics do not present a major macroplastic marine debris threat, i.e. entanglement, the ecotoxicological effects and health risks are apparently evident in many organisms along the food chain and will ultimately affect top predators, including cetaceans. The authors argued that, 'like climate change, more international cooperation is needed to develop conventions, action lists or regulations to improve the problem of microplastic pollution'. Several recent books, including Andrady (2022), underline the importance of this issue and emphasise that, despite the publication of many hundreds of research papers, key aspects of sampling and characterising micro- and nanoplastics, along with their fates and impacts, remain to be determined.

(SOURCE: Zhou, C., Ran, B., Su, C., Liu, W. and Wang, T. 2022. The emerging issue of microplastics in marine environment: A bibliometric analysis from 2004-2020. Mar. Pollut. Bull. 179: 113712, https://doi.org/10.1016/j.marpolbul.2022.113712; Andrady, A.L. (ed.) 2022. Plastics and the Ocean: Origin, Characterization, Fate, and Impacts*. John Wiley & Sons: Hoboken, New Jersey, USA)*

Disease and mortality events

Oil Spills

OIL POLLUTION AT SEA IS ON A MUCH BIGGER SCALE THAN PREVIOUSLY THOUGHT

Although large tanker spills receive public attention, a major input of oil into the marine environment is smaller accidental and operational releases. These releases often manifest as continuous slicks or sheens in shipping routes or coastal areas. However, estimating the input of oil through this cause has previously been difficult. Satellite radar images were used to investigate slicks, analysing more than 500,000 images. Over 450,000 oil slicks were identified, mostly from anthropogenic sources (94%), with just 6% from natural seeps. The proportion of anthropogenic oil sources was 54% in the 1990s. Ninety percent of oil slicks were within 160km of shorelines. The increase in oil slicks is related to an increase in global transportation via shipping. Anthropogenic oil pollution is a much bigger issues than previously thought.

(SOURCE: Dong, Y., Liu, Y., Hu, C., MacDonald, I.R., and Lu, Y. 2022. Chronic oiling in global oceans. Science 376: 1300-1304, https://www.science.org/doi/abs/10.1126/science.abm5940)

Climate change

HIGH LEVELS OF INCREASE OF THE TOP THREE GREENHOUSE GASES

Carbon dioxide levels in the earth's atmosphere increased by 2.13 ppm, to 417.06 ppm, which is 50% higher than preindustrial levels. Atmospheric CO_2 levels were last this high 4.3 million years ago during the mid-Pliocene, when sea levels were 23m higher than today and the average temperature was 4°C higher. In that epoch, the now ice and tundra lands of northern Greenland were covered with forests and shrubland populated by mammoths and reindeer and were up to 19°C warmer. Last year (2022) was the 11th consecutive year CO_2 levels had increased by more than 2 ppm. Before 2013, three consecutive years of ≥2 ppm CO_2 increase annually had never been recorded in 65 years of keeping records. Methane is an even more powerful greenhouse gas, and levels increased in 2022 by 14.0 ppb, to an average of 1,912 ppb. This is the fourth-largest annual increase since 1983 (with other record increases in 2020 and 2021). Methane levels in the atmosphere are currently more than two and a half times preindustrial levels. Eighty-five percent of the increase in methane between 2006 and 2016 was due to agriculture (emissions from livestock and agricultural waste) and from wetlands, with the remaining 15% from fossil fuels. Nitrous oxide, the third-most important greenhouse gas, rose by 1.24 ppb, to 335.7 ppb (the third-largest increase since 2000, with the two highest increases in 2020 and 2021); its levels are now 24% higher than preindustrial levels. The increases in nitrous oxide are due to increasing levels of fertiliser and manure from the expansion and intensification of agriculture.

(SOURCES: Basu, S., Lan, X., Dlugokencky, E., Michel, S., Schwietzke, S., Miller, J.B., Bruhwiler, L., Oh, Y., Tans, P.P., Apadula, F. and Gatti, L.V. 2023. Estimating emissions of methane consistent with atmospheric measurements of methane and $\delta^{13}C$ of methane. Atmospheric Chemistry and Physics 22: 15351-15377, https://doi.org/10.5194/acp-22-15351-2022; Kjær, K.H. et al. 2022. A 2-million-year-old ecosystem in Greenland uncovered by environmental DNA. Nature 612: 283-291, https://doi.org/10.1038/s41586-022-05453-y; NOAA 2023. Greenhouse gases continued to increase rapidly in 2022. NOAA.gov, 5 April, https://www.noaa.gov/news-release/greenhouse-gases-continued-to-increase-rapidly-in-2022)

GLACIERS COULD RETREAT AND SEA LEVELS COULD RISE MUCH FASTER THAN PREVIOUSLY THOUGHT

Since the 1990s, Antarctica and Greenland have lost 6.4 trillion tons of ice, contributing to a global sea level rise of nearly 2cm. Antarctic glaciers have retreated by as much as 50m a day. Glaciers entering the ocean are slowed by grounding along the sea floor, but as melting glaciers retreat toward land, the ice lifts up from the seabed and floats, which causes the glacial ice flow into the ocean to increase. Researchers investigating ice loss at the end of the last ice age found that ice retreated up to 610m per day then. This rate of ice loss is 20 times the rate currently estimated from satellite images, but researchers warn that if the current rate of global warming continues, many glaciers may start to retreat more rapidly than previously estimated, changing the nature of the polar fringes and adding significantly to sea level rise.

(SOURCE: Batchelor, C.L., Christie, F.D., Ottesen, D., Montelli, A., Evans, J., Dowdeswell, E.K., Bjarnadóttir, L.R. and Dowdeswell, J.A. 2023. Rapid, buoyancy-driven ice-sheet retreat of hundreds of metres per day. Nature https://www.nature.com/articles/s41586-023-05876-1)

OCEAN TEMPERATURES AT RECORD LEVELS

Global ocean surface temperature has hit an all-time high (since satellite records began). Data from the US National Oceanic and Atmospheric Administration show that average ocean surface temperatures reached a record 21.1°C (exceeding the previous record temperature in 2016). Due to La Niña conditions in the Pacific, there was a cooling of average ocean surface temperatures since the last record temperatures, but with a switch to a possible El Niño pattern in the tropical Pacific later this year, higher ocean surface temperatures and MHWs are expected. Measurements from the top 2km of the ocean have shown a rapid increase in temperatures since the 1980s. These increasing temperatures have major implications for marine ecosystems and food webs.

(SOURCES: Climate Reanalyzer 2023. Daily Sea Surface Temperature. Climate Change Institute, University of Maine. https://climatereanalyzer.org/clim/sst_daily/; NOAA 2023. Global ocean heat and salt content: seasonal, yearly, and pentadal fields. National Centers for Environmental Information, https://www.ncei.noaa.gov/access/global-ocean-heat-content/)

Warming Oceans Will Reduce the Nutritional Value of Phytoplankton

The physiological adaptation of phytoplankton to a warming world could lead to a reduction in their nutritional value. Microorganisms often respond to changing environmental conditions by 'lipid remodelling' or changing their fat content. The authors predicted that lipid remodelling in marine phytoplankton across a wide range of increasing temperatures and oceanographic conditions would cause phytoplankton to contain more saturated fatty acids and fewer essential unsaturated fatty acids. Animals cannot produce their own essential unsaturated fatty acids and must obtain them through their diet. Therefore, a reduction in these essential nutrients would have a major impact on marine food webs. Lower levels of unsaturated fatty acids in phytoplankton would impair fish reproductive and immune systems, and thereby would negatively affect fisheries and marine species that feed upon fish, including cetaceans.

(SOURCE: Holm, H.C., Fredricks, H.F., Bent, S.M., Lowenstein, D.P., Ossolinski, J.E., Becker, K.W., Johnson, W.M., Schrage, K. and Van Mooy, B.A. 2022. Global ocean lipidomes show a universal relationship between temperature and lipid unsaturation. Science 376: 1487-1491, https://www.science.org/doi/abs/10.1126/science.abn7455)

Greenland Ice Sheet Melting Is Close to an Irreversible Tipping Point

The Greenland Ice Sheet covers approximately 1.7 million km^2; if it melted, there would be a 7m rise in sea level. Between 2003 and 2016, the Ice Sheet lost up to 255 gigatonnes of ice per year. The authors estimated that 1,000 gigatonnes of carbon emissions would cause the southern portion of the Ice Sheet to melt, which would cause a 1.8m sea level rise, and 2,500 gigatonnes of emissions would cause nearly the entire Ice Sheet to melt. Approximately 500 gigatonnes of carbon have already been added to the atmosphere, which means the planet is halfway to half of the Ice Sheet melting. The authors warned that the planet is close to an irreversible tipping point. As the ice sheet melts, its elevation decreases, which exposes it to warmer air, causing a positive feedback loop, accelerating the warming. The authors emphasised that, even if nations manage to achieve the 1.5^{o}C temperature increase limit of the Paris Climate Agreement, this tipping point could still be reached and the Ice Sheet, even if atmospheric CO_2 was reduced to preindustrial levels, would not reform.

(SOURCE: Höning, D., Willeit, M., Calov, R., Klemann, V., Bagge, M. and Ganopolski, A. 2023. Multistability and transient response of the Greenland ice sheet to anthropogenic CO_2 emissions. Geophys. Res. Lett. 50: e2022GL101827, https://doi.org/10.1029/2022GL101827)

The Latest IPCC Report Urges Immediate and Dramatic Reductions in Greenhouse Gas Emissions

The latest Intergovernmental Panel on Climate Change (IPCC) report painted a bleak picture for the near future and highlighted that there has been a lack of sufficient international action on climate change. The report noted that 2011-2020 was 1.1^{o}C warmer than 1850-1900 and, with the current greenhouse gas emission policies in place, the global average temperature will be 3.2^{o}C warmer by 2100 (with the range being 2.5^{o}C to 3.5^{o}C). With such temperatures there will be a 100% likelihood of marine species extinctions in the equatorial and tropical oceans, with widespread extinctions in the Indo-Pacific region. Likewise, fishery yields will decrease by more than 35% in most coastal areas of Africa, Asia and Europe, with decreases of 20-25% along much of the South American coastline (except the most southern regions) and declines of 25-35% along the US and Australian coasts. There is very little chance of limiting global warming to 1.5^{o}C and there is a diminishing chance of limiting warming to 2^{o}C. There needs to be dramatic and immediate decreases in greenhouse gas emissions to avoid reaching these temperature increases by 2100. The report stated that 'Climate change is a threat to human well-being and planetary health … There is a rapidly closing window of opportunity to secure a liveable and sustainable future for all'.

(SOURCE: IPCC 2023. AR6 Synthesis Report. Climate Change 2023*. Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/sixth-assessment-report-cycle/)*

Second Lowest Antarctic Sea Ice Coverage and Changing Southern Ocean Circulation

Lee *et al.* (2023) reported that, in March 2023, average sea ice extent around Antarctica was 2.80 million km^2, the second lowest level on record (it was 100,000km^2 higher than the lowest level recorded in 2017). Due to increasing levels of warm deep ocean water, more ice melting is occurring at depth. This melting ice, as it is less saline and less dense, rises to the ocean surface, forming a layer of fresher, lower density water there. Stratification of the Southern Ocean due to this increased surface freshwater is slowing the vertical movement of water around Antarctica, which has implications for the flow of nutrients to the surface. Moreover, cooling of the Antarctic stratosphere caused by the hole in the ozone layer, coupled with warming tropical regions (caused by greenhouse gases), is leading to Southern Ocean winds becoming stronger, adding to changes in surface circulation. Li *et al.* (2023) projected the circulation of surface water to depth flow to decline by 40% by 2050. This slowing vertical circulation also affects the ocean's ability to absorb CO_2 from the atmosphere, as surface waters quickly reach their carbon-absorbing capacity and then are not replaced by non-carbon-saturated water drawn to the surface by vertical circulation. In addition, this change in vertical circulation opens a pathway for warmer waters to enter the system, which could increase ice melting, causing a positive feedback loop where more freshwater is added to the system, slowing down vertical circulation even further.

(SOURCES: Lee, S.K., Lumpkin, R., Gomez, F., Yeager, S., Lopez, H., Takglis, F., Dong, S., Aguiar, W., Kim, D. and Baringer, M. 2023. Human-induced changes in the global meridional overturning circulation are emerging from the Southern Ocean. Nature Communications Earth and Environment *4, 69, https://www.nature.com/articles/s43247-023-00727-3; NSIDC 2023. From polar dawn to dusk. National Snow and Ice Data Center, 5 April, https://nsidc.org/arcticseaicenews/2023/04/polar-dawn-to-dusk/; Li, Q., England, M.H., Hogg, A.M., Rintoul, S.R. and Morrison, A.K. 2023. Abyssal ocean overturning slowdown and warming driven by Antarctic meltwater. Nature 615: 841-847, https://doi.org/10.1038/s41586-023-05762-w)*

CONCERNS ABOUT OCEAN CARBON SEQUESTRATION AND IMPACTS ON MARINE SPECIES

People are increasingly looking to the oceans as a means of absorbing carbon; however, there are concerns about the potential impacts of these methods of carbon capture on marine ecosystems. For example, ocean fertilisation (adding trace nutrients such as Fe to promote phytoplankton productivity) might result in HABs and decrease light penetration in the water column. Decomposition of excess dead phytoplankton could lead to deoxygenation of ocean waters as well. Other methods of carbon capture include cultivating macroalgae (and then sinking them) and dumping crop waste into the ocean, but these lead to similar concerns about deoxygenation. Direct injection of liquid CO_2 in deep water or below the seafloor could lead to hypercapnia (excessive CO_2), which might suffocate marine species. Adding CO_2 to the ocean might also exacerbate ocean acidification. In summary, suggested methods to sequester carbon into the ocean should be carefully examined, as they may have adverse impacts on marine species, including cetaceans and their prey, ocean ecosystems and marine geochemical cycles.

(SOURCE: Levin, L.A., Alfaro-Lucas, J.M., Colaço, A., Cordes, E.E., Craik, N., Danovaro, R., Hoving, H.J., Ingels, J., Mestre, N.C., Seabrook, S., Thurber, A.R., Vivian, C. and Yasuhara, M. 2023. Deep-sea impacts of climate interventions. Science 379: 978-981, https://www.science.org/doi/abs/10.1126/science.ade7521)

RATE OF SEA LEVEL RISE IS INCREASING

The average global sea level rose 0.27 cm between 2021 to 2022 according to satellite data. This is "the equivalent of adding water from a million Olympic-size swimming pools to the ocean every day for a year". Since 1993, when satellites began to be used to monitor sea level height, the average global sea level has increased by 9.1cm. The annual rate of sea level rise has also been increasing from 2mm per year in 1993 and has more than doubled to 4.4mm per year in 2022. At current rates of increase it will be 6.6 mm per year in 2050. At this rate of sea level rise, by 2040, sea levels could be 9.3cm higher than today.

(SOURCE: NASA 2023. NASA uses 30-year satellite record to track and project rising seas. NASA.gov, 17 March 2023, http://www.nasa.gov/feature/jpl/nasa-uses-30-year-satellite-record-to-track-and-project-rising-seas)

OCEAN ACIDIFICATION IS OCCURRING 3 TO 4 TIMES FASTER IN THE ARCTIC OCEAN

The Arctic Ocean has experienced rapid warming and sea ice loss in recent decades, and ocean acidification has been three to four times higher than in other ocean basins. Melting sea ice is exposing more surface water to the atmosphere, which is promoting a rapid uptake of atmospheric CO_2, leading to sharp declines in pH. The authors predicted increasing acidification, particularly in higher latitudes where sea ice is actively melting.

(SOURCE: Qi, D., Ouyang, Z., Chen, L., Wu, Y., Lei, R., Chen, B., Feely, R.A., Anderson, L.G., Zhong, W., Lin, H. and Polukhin, A. 2022. Climate change drives rapid decadal acidification in the Arctic Ocean from 1994 to 2020. Science 337: 1544-1550, https://www.science.org/doi/abs/10.1126/science.abo0383)

TEMPERATURE INCREASE AND SEA LEVEL RISE PREDICTIONS FOR 2100 EXCEED AGREED LIMITS

Loss of glacier mass affects sea level rise, water resources and natural hazards. Rounce *et al.* (2023) projected glaciers will lose 26% (± 6%, with a +1.5°C temperature increase scenario) to 41% (± 11%, for a +4°C scenario) of their mass by 2100 (relative to 2015). This ice loss corresponds to 9cm (± 2.6cm) to 15.4cm (± 4.4cm) of sea level rise. If countries abide by their climate pledges from the COP26 Paris Climate Agreement meeting, there will be a global mean temperature increase of 2.7°C, leading to 11.5cm (± 4cm) sea level rise by 2100. Matthews and Wynes (2023) reported that human activities have so far caused global temperatures to increase by 1.25°C. The Paris Climate Agreement had a goal of limiting the global temperature increase (from preindustrial levels) to well below 2°C by 2100. During the COVID-19 pandemic, there was a brief decrease in fossil fuel emissions (by 5.4%), but in 2021 emission levels rebounded to 2019 levels. Current emissions will result in a 1.5°C increase over preindustrial levels before 2032. If all countries meet their 2030 emissions reduction targets, temperatures might be kept below a 2.5°C rise by 2100. If nations meet their net zero carbon emissions targets as well, temperatures might be kept to a 1.9°C rise by 2100. However, this is increasingly unlikely due to a lack of action. The authors blamed lack of political and institutional will to reduce greenhouse gas emissions. 'The available evidence does not yet indicate that the world has seriously committed to achieving the 1.5°C goal.' With current policies in place, they projected a 3.2°C increase by 2100.

(SOURCES: Rounce, D.R., Hock, R., Maussion, F., Hugonnet, R., Kochtitzky, W., Huss, M., Berthier, E., Brinkerhoff, D., Compagno, L., Copland, L. and Farinotti, D. 2023. Global glacier change in the 21st century: Every increase in temperature matters. Science 379: 78-83, https://www.science.org/doi/abs/10.1126/science.abo1324; Matthews, H.D. and Wynes, S. 2022. Current global efforts are insufficient to limit warming to 1.5°C. Science 376: 1404-1409, https://www.science.org/doi/abs/10.1126/science.abo3378)

Low Arctic Ice Coverage and Almost Total Loss of Multiyear Ice

In March 2023, the average Arctic sea ice extent was 14.44 million km^2 (which was 990,000km^2 less than the 1981-2010 average ice coverage, but 150,000km^2 above the record low set in March 2017). Ice extent was below average in almost all areas, but particularly in the Sea of Okhotsk and in the Gulf of St Lawrence, and to a lesser extent in the Barents and Bering Seas. Over the 45-year period with satellite records, there has been an annual ice coverage loss of 38,900km^2 per year. Since 1979, there has been an ice coverage loss of 2.28 million km^2 or six and a half times the size of Germany. In addition, there is far less multiyear ice (ice that has survived at least one summer melt season). In the late 1980s, multiyear ice covered 60-65% of the Arctic Ocean, whereas it covered just 33.9% in early March 2023. In the late 1980s, 30-35% of Arctic ice was more than 4 years old - in March 2023, only 3% was this old.

(SOURCES: Sumata, H., de Steur, L., Divine, D.V., Granskog, M.A. and Gerland, S. 2023. Regime shift in Arctic Ocean sea ice thickness. Nature 615: 443-449, https://www.nature.com/articles/s41586-022-05686-x; NSIDC 2023. From polar dawn to dusk. National Snow and Ice Data Center, 5 April, https://nsidc.org/arcticseaicenews/2023/04/polar-dawn-to-dusk/)

Noise impacts

The Noise Impact of Deep Sea Mining

There is increasing interest in deep sea mining, in particular as a source for rare elements required in electronics. The authors estimated the SLs produced by mining devices on the seabed (181 dB re 1 µPa m, 20Hz to 20 kHz), as well as by pumping (183 dB re 1 µPa m, 20Hz to 20kHz) and the mining vessel (188 dB re 1 µPa m, 20Hz to 2kHz), using equipment comparable to that involved in dredging operations. Sound propagation models were then used to predict the spread of underwater mining noise. The authors noted that support ships and sonars would add to the noise footprint. They estimated that, with a single mining platform, a radius of 4-6km would exceed a threshold for cetacean behavioural disturbance (120 dB re 1 µPa). An area of approximately 5.5 million km^2, within a radius of several hundred kilometres, would have sound levels above ambient (assuming fair weather conditions). If multiple platforms were operating simultaneously, the noise footprint would be larger. Some cetacean species react to anthropogenic sound at levels below 120 dB re 1 µPa, so the radius within which behavioural changes occur may be larger for these species. Little is known about how deep-sea species react to underwater sounds, but considering their dark and typically stable environment, they are likely to be highly sensitive to sound and vibration. The lack of data on impacts of deep sea mining noise on marine species is a cause for concern.

(SOURCE: Williams, R., Erbe, C., Duncan, A., Nielsen, K., Washburn, T. and Smith, C. 2022. Noise from deep-sea mining may span vast ocean areas. Science 377: 157-158, https://www.science.org/doi/abs/10.1126/science.abo2804)

ACKNOWLEDGMENTS

The editors thank Stephanie Plön for submitting entries for inclusion. The editors are especially grateful to the Government of Austria and the Animal Welfare Institute for providing support for SOCER preparation, as requested by Resolution 2000-7. We also thank the IWC Secretariat for funding support for SOCER 2023.

REFERENCES

International Whaling Commission. 1998. Chairman's Report of the Forty-Ninth Annual Meeting. Appendix 7. IWC Resolution 1997-7. Resolution on environmental change and cetaceans. *Rep. Int. Whal. Comm.* 48:48-49.

International Whaling Commission. 1999. Chairman's Report of the Fiftieth Annual Meeting. Appendix 6. IWC Resolution 1998-5. Resolution on environmental changes and cetaceans. *Ann. Rep. Int. Whal. Comm.* 1998:43-44.

International Whaling Commission. 2001. Chairman's Report of the Fifty-Second Annual Meeting. Appendix 1. Resolutions adopted during the 52nd annual meeting. IWC Resolution 2000-7. Resolution on environmental change and cetaceans. *Ann. Rep. Int. Whal. Comm.* 2000:56-57.

Stachowitsch, M., Rose, N.A. and Parsons, E.C.M. 2003. State of the cetacean environment report (SOCER) 2003: Second draft. Paper SC/55/E7 presented to the IWC Scientific Committee, May 2003, Berlin (unpublished). 13pp. [Paper available from the Office of this Journal].

APPENDIX 1

Glossary

Glossary of terms

AEP: Auditory evoked potential, a method to measure hearing.

ALDDFG: Abandoned, lost, or discarded fishing gear.

Benthic: Of, relating to or occurring at the bottom of a body of water, such as the ocean.

Bioaccumulate: To increase the concentration of a pollutant within an organism compared to background levels in its diet.

Biomagnify: To increase the concentration of a contaminant from one link in a food chain to another. Pollutant levels are highest in top predators.

CCAMLR: Commission for the Conservation of Antarctic Marine Living Resources.
dB: Decibel - a logarithmic measure of sound pressure level.
Drifter: Floating devices that are transported by currents, mapping current flow.
El Niño: A weather phenomenon in the Pacific Ocean, where trade winds weaken and warm water is pushed back toward the west coast of the Americas.
Endemic (endemism): Native and restricted to a certain place.
Eutrophication: Input of nutrients into an aquatic system, typically associated with excessive plant growth and oxygen depletion.
FAO: Food and Agriculture Organisation (of the United Nations).
Flagship species: Species chosen to raise support for biodiversity conservation in a given place or social context.
Gyre: Large system of rotating ocean currents.
Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1000 Hz).
Hypoxia: Low levels of dissolved oxygen.
IMO: International Maritime Organisation.
La Niña: The opposite of El Niño. A weather phenomenon in the Pacific Ocean, where trade winds are stronger than usual and more warm water is pushed toward Asia. On the west coast of the Americas, upwelling increases and cold, nutrient-rich water rises to the surface. Flooding and drought often follow.
µPa m: Micropascal per metre, a reference level for underwater sound.
MARPOL: The International Convention for the Prevention of Pollution from Ships.
MHW: Marine heatwave.
Microplastics: Plastic particles 0.3-5 mm in diameter, often the result of larger plastic pieces breaking down over time.
MPA: Marine Protected Area.
Mysticete: Baleen whale.
Nanoplastics: Plastic particles less than 1 µm (micrometre) in diameter.
ng g^{-1} lw: Nanogram per gram lipid weight. Lipid weight is a basis of measurement whereby concentrations of a substance are compared to the lipid (fat) content of a material.
Nurdle: Small lentil-sized pieces of plastic that are the building blocks for most plastic products. Nurdles are by definition a microplastic because they are less than 5mm in size.
Ocean acidification: A reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide from the atmosphere.
Odontocete: Toothed whale.
OHI: Ocean Health Index.
PBDE: Polybrominated diphenyl ethers, used as flame retardants.
Pentadal: A group of five days.
Perfluoroalkyl acids: Used as coatings in cookware, furniture, carpets, food packaging and so on. They repel oil, grease and water.
ppb: Parts per billion.
PPE: Personal protective equipment, such as surgical and N95 masks.
ppm: Parts per million.
SL: Source level.
SouSA Consortium: Group founded in 2016 to address the conservation biology of humpback dolphins at a national scale. Members come from different backgrounds, including academia, commercial whale watching companies and associated conservation groups.
SWOT: Strengths, Weaknesses, Opportunities and Threats.
Trophic: Related to feeding, used in ecology to indicate food web positions or levels (e.g. plant, herbivore, carnivore).
Water column: A conceptual column of water extending from the sea surface down to the seafloor.
WHO: World Health Organization (of the United Nations).

Species glossary

Blue whale	*Balaenoptera musculus*		
Common bottlenose dolphin	*Tursiops truncatus*	Scalloped hammerhead shark	*Sphyrna lewini*
Finless porpoise	*Neophocaena phocaenoides*	Shortfin devil rays	*Mobula kuhii*
Humpback whale	*Megaptera novaeangliae*		
Indian Ocean humpback dolphin	*Sousa plumbea*	Antarctic silverfish	*Pleuragramma antarcticum*
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	Krill	Family Euphausiidae (euphausiids)
Long-beaked common dolphin	*Delphinus delphis*		

Heavy metals

As	Arsenic	Cu	Copper	Pb	Lead
Cd	Cadmium	Fe	Iron	Se	Selenium
Cr	Chromium	Hg	Mercury	Zn	Zinc