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State of the Cetacean Environment Report (SOCER) 2018

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INTERNATIONAL WHALING COMMISSION

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INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 and 1998-5, directed the Scientific Committee to provide regular updates on environmental matters that affect cetaceans. Resolution 2000-7 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 2018 SOCER features the **Mediterranean and Black Seas,** summarising key papers and articles published from ca. 2016 through 2018 to date. This year's regional SOCER represents the final year of the most recent cycle, which will be combined in a 5-year compendium (2014: Atlantic Ocean through 2018: Mediterranean and Black Seas) to present to the Commissioners at IWC/67 in Florianopolis, Brazil.

MEDITERRANEAN and BLACK SEAS

General

THE EUROPEAN MARINE STRATEGY FRAMEWORK DIRECTIVE AND CETACEAN CONSERVATION

The European Marine Strategy Framework Directive seeks to implement a precautionary and holistic ecosystem-based approach for managing European marine waters. A questionnaire survey was distributed to nations bordering the Mediterranean and Black Seas to investigate implementation of the Framework, specifically with respect to cetaceans. Those reporting (50% return rate) noted that their national implementation of the Framework did refer to cetaceans, but the specifics of these various implementations were heterogeneous. This unevenness in implementation may hinder transboundary collaboration and, therefore, cetacean conservation. ACCOBAMS could help stimulate collaboration amongst scientists involved in cetacean monitoring and develop transboundary conservation initiatives. The authors note that "Transboundary conservation is most cost-efficient when there is true coordination between countries", which is currently lacking. The authors also suggest that "Marine mammal experts should promote to their respective governments the monitoring of cetaceans at regional, rather than national scales".

(SOURCE: Authier, M., Descroix Commanducci, M.F., Genov, T., Holcer, D., Ridoux, V., Salivas, M., Santos, M.B., and Spitz, J. 2017. Cetacean conservation in the Mediterranean and Black Seas: Fostering transboundary collaboration through the European Marine Strategy Framework Directive. *Mar. Pol.* 82: 98-103)

NEW CONSERVATION ACTION PLAN FOR CETACEANS IN ISRAELI WATERS

Israel has 180 km of coast on the Mediterranean Sea and has legal influence over 26,000 km^2 of ocean surface area, with 12 species of cetaceans recorded from this area. An Action Plan for 2017-2022 seeks to "ensure that marine mammal populations in the waters of Israel enjoy a 'favourable conservation status'… arising from a combination of legislative, management, research, education and awareness initiatives". The plan notes bycatch, underwater noise and prey depletion as the highest priority threats to Israeli cetaceans. Chemical pollution, climate change and habitat degradation are possible major threats, and marine debris, directed takes, ship strikes, oil pollution and disturbance are possible minor threats. The plan outlines numerous legislative, institutional and research initiatives, as well as proposals for local capacity building, cetacean conservation and public outreach.

(SOURCE: Bearzi G. 2017. *Action Plan for Marine Mammals in Israel*, 2017–2022. Israel Marine Mammal Research & Assistance Center (IMMRAC), Michmoret, Israel)

THE RECENT DECLINE OF THE BLACK SEA HARBOUR PORPOISE – A HISTORICAL CONTEXT

An analysis of archaeological specimens of cetaceans from the Black Sea (from 800 to 1600 years ago) suggests that cetaceans were subjected to fisheries bycatch, as well as directed hunting, in the past. Therefore, there has been a long history of anthropogenic takes of cetaceans in the Black Sea, from the late Classical through the medieval era. Genetic analyses of harbour porpoise specimens suggest that, despite these removals, there was an expansion of porpoise numbers in the Black Sea, followed by a dramatic decline over the past century. This decline illustrates that recent anthropogenic removals of porpoises greatly exceed the historical impact of fisheries bycatch and directed takes.

(SOURCE: Biard, V., Gol'din, P., Gladilina, E., Vishnyakova, K., McGrath, K., Vieira, F.G., Wales N., Fontaine, M. C., Speller, C., and Olsen, M.T. 2017. Genomic and proteomic identification of Late Holocene remains: Setting baselines for Black Sea odontocetes. *J. Archaeol. Sci.: Rep.* 15: 262-271)

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A DISTINCT HARBOUR PORPOISE POPULATION IN THE AZOV SEA

The Azov Sea is a small enclosed body of water (37,000 km^2) that connects to the Black Sea via the narrow Kerch Strait. The sea is seasonally occupied by harbour porpoises. Analyses of porpoise skulls showed that the Azov and Black Sea porpoises are distinct from North Atlantic skulls, i.e., supporting their status as part of the subspecies *Phocoena phocoena relicta*. However, the skulls of Azov Sea porpoises were distinct from Black Sea porpoises, suggesting that the Azov Sea porpoise is a genetically distinct population, which would warrant special conservation consideration.

(SOURCES: Gol'din, P. and Vishnyakova, K. 2016. Habitat shapes skull profile of small cetaceans: Evidence from geographical variation in Black Sea harbour porpoises (*Phocoena phocoena relicta*). *Zoomorphology* 135(3): 387-393; Gol'din, P.E. and Vishnyakova, K.A. 2015. Differences in skull size of harbour porpoises, *Phocoena phocoena* (Cetacea), in the Sea of Azov and the Black Sea: Evidence for different morphotypes and populations. *Vestn. Zool.* 49(2): 171-180)

FIRST GLOBAL INTEGRATED MARINE ASSESSMENT: MEDITERRANEAN SEA

A major UN overview of the world's oceans noted that the Mediterranean Sea is a marine biodiversity hotspot (ca. 17,000 species). This includes nine species of marine mammals (five of the family Delphinidae and one each of Ziphiidae, Physeteridae, Balaenopteridae and Phocidae). Its habitats and ecosystem types are also diverse. At present, habitat loss and degradation, followed by fishing, climate change, pollution, eutrophication and the establishment of invasive species are the major threats to most of the taxonomic groups and habitats. These threats are all expected to increase in the future, especially climate change and habitat degradation.

(SOURCE: Inniss, L. and Simcock, A. (Joint coordinators); Rice, J. (Lead member of 14 contributors). 2016. The first global integrated marine assessment: World ocean assessment I. *United Nations, Chapter 36A:* p. 18-20, *http://www.un.org/Depts/los/global_reporting/WOA_RPROC/Chapter_36A.pdf*)

SURVEY GAPS FOR CETACEANS IN THE EASTERN AND SOUTHERN MEDITERRANEAN

An analysis of cetacean surveys found there were serious gaps in survey coverage in the eastern and southern Mediterranean Sea. This means that there is a gap in our understanding of cetacean distribution, abundance and environmental factors in these regions of the Mediterranean.

(SOURCE: Mannocci, L., Roberts, J.J., Halpin, P.N., Authier, M., Boisseau, O., Bradai, M.N., Cañadas, A., Chicote, C., David, L., Di-Méglio, N., Fortuna, C.M., Frantzis, A., Gazo, M., Genov, T., Hammond, P.S., Holcer, D., Kaschner, K., Kerem, D., Lauriano, G., Lewis, T., Notarbartolo di Sciara, G., Panigada, S., Raga, J.A., Scheinin, A., Ridoux, V., Vella, A., and Vella, J. 2018. Assessing cetacean surveys throughout the Mediterranean Sea: A gap analysis in environmental space. *Sci. Rep.-UK* 8: 3126, 1-14, doi:10.1038/s41598-018-19842-9)

MARINE ISSUES IN THE MEDITERRANEAN SEA

This book on Mediterranean marine mammals is a valuable contribution to conservation efforts, presenting the latest information on cetaceans and their habits, as well as attempting to bridge the gap between scientific insights and policy. The Mediterranean Sea is a hotspot of marine and coastal diversity. Although no cetacean species is endemic here, unique populations have formed, requiring special conservation consideration. Of the 12 common marine mammal species, six are considered Mediterranean 'subpopulations' and are listed as Threatened on the IUCN's Red List. Many decision-makers are apparently unaware of "how serious the predicament is for these species and their fragile habitat". The first chapter outlines the Mediterranean regions and the overall status and threats of their marine mammals. The remaining chapters are devoted to key species such as sperm, fin and Cuvier's beaked whale, killer whales, long-finned pilot whales, and Risso's, rough-toothed and bottlenose dolphins, as well as to selected regions. The overall threats are identified as naval sonar, seismic exploration, whale watching disturbance, ship strikes, epizootics, fisheries, pollution, coastal development and climate change. The final chapter discusses international legal conservation frameworks, regional agreements (e.g., ACCOBAMS) and specific treaties (e.g., Pelagos Sanctuary). The authors conclude by underlining that "what is probably lacking are specific provisions having a legally binding nature that directly address a number of threats affecting Mediterranean marine mammals, such as underwater noise, collisions with ships, bycatch in fishing gear and ingestion of plastic litter".

(SOURCE: Notarbartolo di Sciara, G., Podestà, M., and Curry, B.E. (eds). 2016. *Advances in Marine Biology Vol. 75: Mediterranean Marine Mammal Ecology and Conservation.* Elsevier, London. 428 pp.)

OCEAN HEALTH INDEX AND THE MEDITERRANEAN SEA

The Ocean Health Index, compiled by the University of California at Santa Barbara, has released its third annual update. It is based on 10 ecological, economical and societal categories or 'goals', each of which is measured and scored based on four dimensions (status, trend, pressures and resilience). By country, the values diverge considerably around the Mediterranean, from a low ranking for Libya (ranking 220 out of 220, index score 44 out of 100) to a high for Malta (rank 19, score 79). For comparison, the overall health of the oceans globally is 70 out of 100 points. Six of the nine Mediterranean countries evaluated lie below this global average (although some only marginally so).

(SOURCE: *http://www.oceanhealthindex.org*)

MARINE PROTECTED AREAS IN THE MEDITERRANEAN SEA

CBD Aichi Target 11 seeks to protect at least 10% of important marine and coastal habitats, with MPAs being the main global strategy for the conservation of marine biodiversity. The Mediterranean Sea contains variously designated protected areas: Natura 2000 sites, national sites, Ramsar sites, Specially Protected Areas of Mediterranean Importance, the Pelagos Sanctuary and Biosphere Reserves. Mediterranean MPAs are very

unevenly distributed, with 80% concentrated in just three countries in the northwest part of the basin. This geographic distribution can be improved, although size, spacing and shape of existing MPAs are favourable: one third, for example, are bigger than the average ecological threshold of 20 km^2. However, these reasonably good MPA designs are apparently 'accidental', i.e., the result of largely independent national and regional nature conservation processes. Efforts to consolidate an ecologically coherent network of Mediterranean MPAs are clearly required.

(SOURCE: Rodríguez-Rodríguez, D., Rodríguez, J., Blanco, J.M., and Malak, D.A. 2016. Marine protected area design patterns in the Mediterranean Sea: Implications for conservation. *Mar. Pollut. Bull*. 110:335-342, *https://doi.org/10.1016/j.marpolbul.2016.06.044*)

Habitat degradation

General

CETACEAN ABUNDANCE AND ECOSYSTEM TRENDS IN THE NORTHWEST MEDITERRANEAN

Trends in cetacean abundance were investigated via sighting data from ship-board surveys (1990-2014) covering an area of approximately 29,000 km^2 in the northwest Mediterranean, and via strandings data collected from the Ligurian coast (1986-2014). The analysis revealed a significant annual increasing trend in sightings of striped dolphins and sperm whales but a significant decrease in encounters with fin whales and Risso's dolphins. No trends were found for Cuvier's beaked whales. Striped and Risso's dolphin strandings decreased over time, but fin whale strandings increased. The decrease in striped dolphin strandings was influenced by a spike in mortality from a morbillivirus outbreak early in the period. Examining strandings both spatially and temporally, fin whales and striped dolphins appeared to be shifting northwards into more coastal waters, while Risso's dolphins shifted into more oceanic waters. No trends were found for sperm or Cuvier's beaked whales. Risso's dolphin and sperm whale encounter rates appeared to be associated with sea surface temperature and surface water chlorophyll levels. Striped dolphin and fin whale encounter rates were correlated, respectively, to the number of fishing boats (negatively) and number of ferries (positively), the former suggesting a conflict between cetaceans and fishing vessels. Moreover, sperm whale group size was inversely correlated to the number of boats. The relative abundance of striped and Risso's dolphins and sperm and fin whales might be correlated with the concurrent decreasing productivity in the region (as measured by decreasing chlorophyll and fishery productivity).

(SOURCE: Azzellino, A., Airoldi, S., Lanfredi, C., Podestà, M. and Zanardelli, M. 2017. Cetacean response to environmental and anthropogenic drivers of change: Results of a 25-year distribution study in the northwestern Mediterranean Sea. *Deep Sea Res. Part II: Tropic. Stud. Oceanogr.* 146: 104-117)

NARROW ECOLOGICAL NICHE OF MEDITERRANEAN FIN WHALES MAKES THEM VULNERABLE TO ANTHROPOGENIC CHANGE

An isotopic analysis was conducted to investigate the diet and ecological niche of fin whales in the Mediterranean Sea and North Atlantic. The analysis showed that Mediterranean fin whales, which are known to feed mainly on krill, had a much narrower dietary niche than the Atlantic whales, which have a more diverse diet. The authors suggest that a narrow ecological niche makes Mediterranean fin whales "more susceptible to ecosystem fragmentation and other anthropogenic impacts".

(SOURCE: Das, K., Holleville, O., Ryan, C., Berrow, S., Gilles, A., Ody, D. and Michel, L.N. 2017. Isotopic niches of fin whales from the Mediterranean Sea and the Celtic Sea (North Atlantic). *Mar. Environ. Res.* 127: 75-83)

Fisheries interactions

SICILIAN FISHING CAPACITY DECREASE IS CORRELATED WITH DOLPHIN STRANDINGS DECREASE

This analysis compared strandings of bottlenose and striped dolphins in Sicily with values of engine power, based on fishing vessels registered in 48 Sicilian ports, from 1995 through 2012. Fishing capacity decreased during this period, as did strandings; this correlation was statistically significant. Strandings tended to be clustered near ports with high fishing capacity. Bottlenose dolphin strandings were more frequent where bottom otter trawls were more frequently used. Therefore, while fishing capacity can be an indicator of the level of threat to cetaceans, it can also predict decreases in dolphin mortality.

(SOURCE: Crosti, R., Arcangeli, A., Romeo, T. and Andaloro, F. 2017. Assessing the relationship between cetacean strandings (*Tursiops truncatus* and *Stenella coeruleoalba*) and fishery pressure indicators in Sicily (Mediterranean Sea) within the framework of the EU Habitats Directive. *Eur. J. Wildlife Res.* 63: 55-68, *https://doi.org/10.1007/s10344-017-1111-8*)

SEASONAL CLOSURE OF GILLNET FISHERIES IN THE AZOV SEA MIGHT REDUCE BYCATCH LEVELS

Stranding and bycatch data for harbour porpoises from 1999 to 2013 in the Azov Sea showed a peak in strandings in July and August, a period when females are lactating and very young animals are newly foraging independently. The stranding peak did not coincide with the regional peak of the turbot, shad and sturgeon fisheries, which is in the spring. Bycatch reduction could therefore be achieved by closing coastal gillnet fisheries in the peak stranding period. Because this is not peak fishing season, such time-area closures would minimise the economic impact on local fisheries.

(SOURCE: Vishnyakova, K. and Gol'din, P. 2015. Seasonality of strandings and bycatch of harbour porpoises in the Sea of Azov: The effects of fisheries, weather conditions and life history. *ICES J. Mar. Sci.* 72(3): 981-991)

Marine Debris

COASTAL MACRO-LITTER IN THE TURKISH MEDITERRANEAN SEA

Thirteen beaches along the northeast Mediterranean shores of Turkey yielded an average density of 0.9 litter items/m^2. Eight of these beaches were classified either as 'dirty' or 'extremely dirty'. Litter from convenience

food consumption and smoking made up more than half of the litter collected. Agricultural, industrial and fisheries-related items contributed only 6%. Plastic items made up over 89%. Less than 4% had been transported from neighbouring countries. The researchers identified direct deposition as the main source of this litter and underlined poor local awareness and the need for educational programs to help reduce coastal litter.

(SOURCE: Aydin, C., Güven, O., Salihoglu, B., and Kideys, A.E. 2016. The influence of land use on coastal litter: An approach to identify abundance and sources in the coastal area of Cilician Basin, Turkey. *Turk. J. Fish. Aquat. Sci.* 16: 29-39, doi: 10.4194/1303-2712-v16_1_04)

MICROPLASTICS FOUND IN PREY FISH OF CETACEANS

Three commercially relevant demersal fish species - the lesser spotted dogfish, European hake and red mullet - are currently used as biomonitors for marine pollution in Spain. The stomachs of 212 specimens revealed that about 18% contained microplastics. Red mullet had the highest abundance (33%) in the Mediterranean (Barcelona). Most of the documented material was fibres, with potential sources being hygiene and cosmetic products, textiles and industrial fishing gear (especially neutrally or negatively buoyant nylon). Laboratory studies have shown that microplastics may have the ability to enter and propagate through the marine food web. Hake and mullet are prey of Mediterranean cetaceans, pointing to a potential direct transfer of marine debris to dolphins and porpoises.

(SOURCE: Bellas, J., Martínez-Armental, J., Martínez-Cámara, A., Besada, V., and Martínez-Gomez, C. 2016. Ingestion of microplastics by demersal fish from Spanish Atlantic and Mediterranean coasts. *Mar. Pollut. Bull.* 109: 55-60, *https://doi.org/10.1016/j.marpolbul.2016.06.026*)

PLASTIC IN THE MEDITERRANEAN SEA

The Mediterranean Sea is heavily affected by marine debris. The average density of plastic (1 item/4 m^2) and its frequency (100% of all sites sampled) are comparable to the accumulation zones described for the five subtropical gyres (e.g., Great Pacific Garbage Patch), and the proportion of large objects is even higher than in those gyres. The authors attribute this to high human pressure and the semi-enclosed geography of the Mediterranean.

(SOURCE: Cózar, A., Sanz-Martin, M., Marti, E., Gonzalez-Gordillo, J.I., Ubeda, B., Galvez, J.A., Irigoien, X., and Duarte, C.M. 2015. Plastic accumulation in the Mediterranean Sea. *PLOS ONE*, doi:10.1371/journalpone.0121762)

FLOATING MACRO-LITTER AND CETACEANS: THEY WILL MEET

This is one of the first studies to directly compare the distribution of marine debris with cetacean presence. The researchers recorded 1993 floating items (overall density: 15 items/km^2) along the coast of France between Marseille and Monaco (281 transects, more than 5000 km travelled). Most items were plastic bags/packaging. Sightings (n = 259, of 2194 individuals) of six species of cetaceans corresponded by ca. 50% with plastic distribution. Considering the ingestion, entanglement and strangulation risk of cetaceans in marine litter, this high overlap and thus potential for interaction is cause for concern, particularly for endangered sperm whales. Importantly, this study's transects partially overlapped with the Pelagos Sanctuary, revealing a sensitive situation. The authors note that they monitored only the 'tip of the iceberg' because, in the Mediterranean, litter densities on the seafloor are higher than for floating litter. They call for actions to reduce the presence of macro-litter at sea.

(SOURCE: Di-Méglio, N. and Campana, I. 2017. Floating macro-litter along the Mediterranean French coast: Composition, density, distribution and overlap with cetacean range. *Mar. Pollut. Bull.* 118: 115-166, *https://doi.org/10.1016/j.marpolbul.2017.02.026*)

MICROPLASTICS POSE A THREAT TO MEDITERRANEAN FIN WHALES

The level of microplastics, as well as the toxicology of fin whale populations, were compared between the Gulf of California and the Pelagos Sanctuary in the Mediterranean Sea. Concentrations of microplastics in the Gulf of California ranged up to 0.14 items/m^3, while the Mediterranean had levels several times higher (up to 9.67 items/m^3, mean: 0.31 ± 1.17 items/m^3). Furthermore, phthalate and organochlorine contaminant levels, as well as biomarker responses, were significantly higher in Mediterranean fin whales. There was a clear overlap between areas with fin whales feeding and microplastic high density in the Ligurian and Sardinian seas. The authors conclude that "Mediterranean fin whales appear to be exposed to absorbed and constituent contaminants of plastic, as a result of direct and indirect ingestion of microplastic, macroplastic and contaminated prey. These results represent a warning for the vulnerable Mediterranean fin whale population". See Table 1 for biomarker and contaminant values.

(SOURCE: Fossi, M.C., Marsili, L., Baini, M., Giannetti, M., Coppola, D., Guerranti, C., Caliani, I., Minutoli, R., Lauriano, G., Finoia, M.G., Rubegni, F., Panigada, S., Bérubé, M., Urbán Ramírez, J., Panti, C. 2016. Fin whales and microplastics: The Mediterranean Sea and the Sea of Cortez scenarios. *Environ. Poll.* 209: 68-78)

PLASTIC DEBRIS IN WHALE PROTECTED AREA

Modelling of ocean currents with field data confirmed that the Pelagos Sanctuary, a Specially Protected Area of Mediterranean Importance, suffers heavy impacts from micro- and macro-plastics. The most abundant polymer was polyethylene, suggesting fragmentation of larger packaging as the primary source. There was a large overlap between marine litter hotspots and fin whale feeding habitat. This is an important contribution for risk assessment of fin whale exposure to microplastics.

(SOURCE: Fossi, M.C., Romeo, T., Baini, M., Panti, C., Marsili, L., Campani, T., Canese, S., Galgani, F., Druon, J.-N., Airoldi, S., Taddei, S., Fattorini, M., Brandini, C., and Lapucci, C. 2017. Plastic debris occurrence, convergence areas and fin whales feeding ground

in the Mediterranean Marine Protected Area Pelagos Sanctuary: A modelling approach. *Front. Mar. Sci* 4: 167, *https://doi.org/10.3389/fmars.2017.00167*)

HIGH SEA SURFACE MICROPLASTIC DENSITIES IN NORTHERN ADRIATIC SEA

Seventeen trawls over a 20-month period revealed abundant microplastics in the Slovenian part of the northern Adriatic. The average concentration was 406 x 10^3 particles/km^2, equivalent to 5.41 particles/m^3. Most of the analysed particles were polyethylene. This is amongst the highest concentrations reported in the Mediterranean, further corroborating the Mediterranean as one of the world's marine litter hotspots.

(SOURCE: Gajšt, T., Bizjak, T., Palatinus, A., Liubartseva, S., and Kržan, A. 2016. Sea surface microplastics in Slovenian part of the Northern Adriatic. *Mar. Pollut. Bull*. 113:392-399, *https://doi.org/10.1016/j.marpolbul.2016.10.031*)

FISHING ACTIVITY AND MERCHANT SHIPS ASSOCIATED WITH MACRO-LITTER IN SPAIN

The Mediterranean Sea region produces the highest amounts of municipal waste per person per year in the world. Marine litter densities are more than 100,000 items/km^2 on the seafloor close to metropolitan areas (mass occasionally greater than that of megafauna) and the fourth highest concentration of floating debris in the world. This study revealed increasing densities in the Gulf of Alicante (Spain) from the open sea to the coast. By weight, 76% was plastic, metal and glass. Fishing activity was identified as being the source of nearly 30% of this litter. Overall, likely sources were merchant ships in open waters and recreational and fishing vessels in coastal waters. The latter reflects (a) the practice of discarding old or damaged gear and tackle overboard and (b) unintentional losses due to snagging, especially on rocky grounds closer to shore. This type of debris poses an entanglement threat to cetaceans. The authors encourage 'marine retention programmes' on trawlers to reduce marine litter.

(SOURCE: García-Rivera, S., Sánchez Lizaso, J.L., and Bellido Millán, J.M. 2017. Composition, spatial distribution and sources of macro-marine litter on the Gulf of Alicante seafloor (Spanish Mediterranean). *Mar. Pollut. Bull.* 119: 110-118, *https://doi.org/10.1016/j.marpolbul.2017.06.022*)

BULGARIAN BLACK SEA COAST HEAVILY POLLUTED WITH LITTER

The Bulgarian Black Sea has received little attention regarding marine litter. The eight beaches studied along the Bulgarian coastline were classified as being highly polluted with litter. Artificial polymer materials made up nearly 85% of this material. Cigarette butts, followed by plastic caps/lids and cups, were the most abundant items. Litter densities were highest on urban beaches, indicating that recreational activities associated with tourists and campers were key sources. The data collected in this and other studies in European seas are important for the European Marine Strategy Framework Directive, designed to achieve or maintain 'Good Environmental Status' for all European seas by 2020. Marine litter is one of 11 'descriptors' considered for determining this status.

(SOURCE: Simeonova, A., Chuturkova, R, and Yaneva, V. 2017. Seasonal dynamics of marine litter along the Bulgarian Black Sea coast. *Mar. Pollut. Bull.* 119: 110-118, *https://doi.org/10.1016/j.marpolbul.2017.03.035*)

FIRST MARINE LITTER STUDY ON THE SOUTHEAST BLACK SEA COAST

Nine beaches along the Turkish southeast coast of the Black Sea yielded a mean density of 0.16 litter items/m^2 by number and 3.6 g/m^2 by weight. Plastic marine debris is known to be the most abundant litter category in Turkish waters and was also the most abundant along the southeast coast of the Black Sea, followed by Styrofoam and fabric. Although the values were at the lower end of the range reported from other regions, the authors identify the source as inappropriately stored or disposed-of wastes and underline the role of major rivers and streams that empty into the Black Sea.

(SOURCE: Terzi, Y. and Seyhan, K. 2017. Seasonal and spatial variations of marine litter on the south-eastern Black Sea coast. *Mar. Pollut. Bull.* 120: 154-158, *http://dx.doi.org/10.1016/j.marpolbul.2017.04.041*)

Ship strikes

SPERM WHALES AT RISK OF SHIP STRIKES IN NORTHWEST MEDITERRANEAN SEA

Collisions with large vessels may be a conservation issue for the endangered Mediterranean sperm whale population. Comparing the sightings of sperm whales with ship traffic density yielded maps of collision risk in relation to vessel speed. The calculations show that the whales were more at risk from merchant vessels along the French and Italian continental coasts, and by conventional ferries on the east side of the islands of Corsica and Sardinia in the Pelagos Sanctuary. The authors estimated that 74 animals could be at risk of being struck by ships during the summer months in the Pelagos Sanctuary. The authors also noted that 9% of photo-identified sperm whales had scars attributed to ship strikes. These results provide a basis for defining high-risk areas and initiating mitigation measures that encompass commercial vessels, leisure boats and naval boats. While enforced shipping lanes avoid areas of high whale density, observers to detect whales (with infra-red vision at night), early warning systems and training for ships' crews could also be mitigation measures to reduce ship strike risk.

(SOURCE: Di-Meglio, N., David, L., and Monestiez, P. In press. Sperm whale ship strikes in the Pelagos Sanctuary and adjacent waters: assessing and mapping collision risks in summer. *J. Cetacean Res. Manage.* In press)

Chemical pollution

PYRETHROID INSECTICIDE FOUND IN STRIPED DOLPHINS FROM THE ALBORÁN SEA

Insecticide pyrethroid levels were determined from the liver of striped dolphins in the Alborán Sea. Pyrethroids were detected in 87% of the specimens, with a mean total concentration of 300 µg/kg lipid weight. The bioaccumulation of these insecticides was unlike that of POPs: the concentration increased slightly from calves

to juveniles, but there was little difference between juveniles and adults. These levels are a cause for concern, although their toxicological impact is currently unknown. See Table 2 for values.

(SOURCE: Aznar-Alemany, Ò., Giménez, J., de Stephanis, R., Eljarrat, E. and Barceló, D. 2017. Insecticide pyrethroids in liver of striped dolphin from the Mediterranean Sea. *Environ. Pollut.* 225: 346-353)

HIGH HEAVY METAL CONCENTRATIONS IN THE EASTERN BLACK SEA

The contamination of Black Sea waters, sediments and organisms with a wide range of pollutants has become a matter of great concern. The main metal pollution problem in the eastern Black Sea coast of Turkey is related to agricultural run-off, sewage effluents with deficient or no treatment, and river-borne wastes from mines. The levels of metals in a bivalve and snail species were significantly above tolerable levels. Due to the bioaccumulation potential of heavy metals, such high levels are a potential cause for concern for higher-level predators such as cetaceans.

(SOURCE: Baltas, H., Sirin, M., Dalgic, G., Bayrak, E.Y., and Akdeniz, A. 2017. Assessment of metal concentrations (Cu, Zn, and Pb) in seawater, sediment and biota samples in the coastal area of Eastern Black Sea, Turkey. *Mar. Pollut. Bull.* 122: 475-482, *http://dx.doi.org/10.1016/j.marpolbul.2017.06.059*)

ENDOCRINE-DISRUPTING CHEMICALS FOUND IN FISH OFF SICILY

Endocrine-disrupting chemicals can show harmful effects on the reproduction and development of aquatic animals by interfering with normal hormonal levels and processes. This study used an improved method to detect three such compounds in all samples of red mullet collected from two sites (characterised by different degrees of pollution) off Sicily. The similar levels in both sites point to background values attributable to the global distribution of these contaminants rather than a local source. The three pollutants belong to category 1 (clear evidence of endocrine-disrupting activity) of Endocrine Disruptor Chemicals. The levels were sufficiently high to prompt the researchers to point to a potential risk for the health of aquatic animals, the Mediterranean Sea ecosystem, and the local human population for whom red mullet is a food source. Red mullet is also a prey species for dolphins.

(SOURCE: Errico, S., Nicolucci, C., Migliaccio, M., Micale, V., Mita, D.G., and Diano, N. 2017. Analysis and occurrence of some phenol endocrine disruptors in two marine sites of the northern coast of Sicily (Italy). *Mar. Pollut. Bull.* 120: 68-74, *http:///dx.doi.org/10.016/j.marpolbul.2017.04.061*)

HIGH LEVELS OF PCBS FOUND IN THREE MEDITERRANEAN CETACEANS

PCB levels in bottlenose and striped dolphins in Europe were amongst the highest recorded levels in cetaceans globally, exceeding all known PCB toxicity thresholds for marine mammals. In the western Mediterranean Sea (1990–2009), PCB concentrations in striped dolphins showed a marked decline after 1990 and then stabilised from 2003 to 2008, but still consistently exceeded all mammalian toxicity thresholds. Although they were not as high as PCB levels in the UK and Ireland, levels in killer whales from the Strait of Gibraltar were also potentially toxic. PCBs can lead to immune system suppression and it was noted that, for example, distemper due to cetacean morbillivirus infection was frequently seen in Mediterranean striped dolphins, and various lesions were observed in bottlenose dolphins and killer whales. The Mediterranean Sea is a global PCB hotspot and most of its cetacean species have declined over decades. The authors state that "Without significant mitigation, PCBs will continue to drive population declines or suppress population recovery in Europe for many decades to come". Despite regulations and mitigation measures to reduce PCB pollution, their biomagnification in marine food webs continues to cause severe impacts amongst cetacean top predators in European seas. See Table 3 for values.

(SOURCE: Jepson, P.D., Deaville, R., Barber, J.L., Aguilar, À., Borrell, A., Murphy, S., Barry, J., Brownlow, A., Barnett, J., Berrow, S., Cunningham, A.A., Davison, N.J., ten Doeschate, M., Esteban, R., Ferreira, M., Foote, A.D., Genov, T., Giménez, J., Loveridge, J., Llavona, Á., Martin, V., Maxwell, D.L., Papachlimitzou, A., Penrose, R., Perkins, M.W., Smith, B., de Stephanis, R., Tregenza, N., Verborgh, P., Fernandez, A., and Law, R.J. 2016. PCB pollution continues to impact populations of orcas and other dolphins in European waters. *Sci. Rep.-UK* 6:18573)

GENETIC ANALYSES OF SKIN SAMPLES REVEAL CONTAMINATION HOTSPOTS

Skin samples of stranded specimens of four cetacean species (bottlenose, striped and Risso's dolphins, fin whales) were examined for genetic markers specific to contaminants of emerging concern. Animals from three basins (Ionian, Tyrrhenian and Adriatic) were sampled. Three of four markers tested showed higher expression in the samples collected from the Adriatic. The researchers highlighted the role freshly stranded specimens can play in determining the region from which individual cetaceans come and the pollution levels there.

(SOURCE: Mancia, A., Lunardi, D., and Abelli, L. 2018. The chronicles of the contaminated Mediterranean seas: A story told by the cetaceans' skin genes. *Mar. Pollut. Bull.* 127: 10-14, *https://doi.org/10.1016/j.marpolbul.2017.11.037*)

HIGH HEAVY METAL CONCENTRATIONS IN HUMAN FOOD (AND DOLPHIN PREY) IN THE AEGEAN SEA

The levels of Hg, Cd, Pb, Cr, Cu and Zn were measured in four species of fish - annular seabream, common pandora, European hake and red mullet - along the Turkish coast of the Aegean Sea. In one of the two bays sampled, the levels of Cd and Pb were above the FAO's tolerable limits for three species, and the levels of Hg were at the maximum permitted limits for two species. Accordingly, the consumption of red mullet and common pandora in this area is potentially hazardous to human health due to Hg concentrations. Dolphins are also known to prey on these species.

(SOURCE: Pazi, I., Gonul, L.G., Kucuksezgin, F., Avaz, G., Tolun, L. Unluoglu, A., Karaaslan, Y., Gucver, S.M., Orhon, A.K., Siltu, E., and Olmuz, G. 2017. Potential risk assessment of metals in edible fish species for human consumption from the Eastern Aegean Sea. *Mar. Pollut. Bull.* 120: 409-413, *https://doi.org/10.1016/j.marpolbul.2017.05.004*)

CHEMICALS ASSOCIATED WITH PLASTICS CONCENTRATED IN SEA TURTLES

Sea turtles (one leatherback, 12 loggerhead) stranded along the Sicilian coast were examined for phthalates, chemicals used in the plastics industry. The total concentrations of the four phthalates examined were high in all tissues. The levels in fat were comparable to those found in marine mammals, underlining that these chemicals leach from plastics and enter the food chain. This supports the potential of monitoring these substances as tracers for microplastic ingestion, and the authors call for efforts to adopt a common plastics waste management policy amongst all Mediterranean countries.

(SOURCE: Savoca, D., Arculeo, M., Barreca, S., Buscemi, S., Caracappa, S., Gentile, A., Persichetti, M.F., and Pacem A. 2018. Chasing phthalates in tissues of marine turtles from the Mediterranean Sea. *Mar. Pollut. Bull*. 127: 165-169, *https://doi.org/10.1016/j.marpolbul.2017.11.069*)

TRACE ELEMENTS IN MEDITERRANEAN STRIPED DOLPHINS

The examination of trace elements (Hg, Se, Cd, Cu, Zn, Fe, Mn and As) in seven specimens of striped dolphin stranded along the Israeli coast from 2006-2011 showed no change from an earlier series beginning in 2001. The Hg values were high (and higher than in other seas), but might reflect the relatively high natural background level of Hg in the Mediterranean. The pathology findings included meningoencephalitis, pneumonia and hepatitis (but no DMV). Striped dolphins have suffered four DMV epidemics (1990-1992, 2006-2008, 2011 and 2013) in this area. This suggests a prolonged DMV circulation in the Western Mediterranean along with an inadequate level of antiviral immunity. This compromised immunity may be caused or aggravated by pollutants. This would impact the health and conservation status of Mediterranean striped dolphins (currently listed as Vulnerable on the IUCN Red List), calling for continued monitoring of the concentrations of heavy metals and other pollutants in this species.

(SOURCE: Shoham-Frider, E., Goffman, O., Harlavan, Y., Kress, N., Morick, D., Roditi-Elasar, M., Shefer, E., and Kerem, D. 2016. Trace elements in striped dolphins (*Stenella coeruleoalba*) from the Eastern Mediterranean: A 10-years perspective. *Mar. Pollut. Bull.* 109: 624-632, *http://doi.org/10.1016/j.marpolbul.2016.05.021*)

TRACE ELEMENT LEVELS IN MEDITERRANEAN CETACEANS AS ECOLOGICAL INDICATORS

See Table 4 for values measured in sperm whales and bottlenose dolphins.

(SOURCES: Monteiro, S.S., Torres, J., Ferreira, M., Marçalo, A., Nicolau, L., Vingada, J.V. and Eira, C. 2016. Ecological variables influencing trace element concentrations in bottlenose dolphins (*Tursiops truncatus*, Montagu 1821) stranded in continental Portugal. *Sci. Total Environ.* 544: 837-844; Squadrone, S., Brizio, P., Chiaravalle, E. and Abete, M.C. 2018. Sperm whales (*Physeter macrocephalus*), found stranded along the Adriatic coast (Southern Italy, Mediterranean Sea), as bioindicators of essential and non-essential trace elements in the environment. *Ecol. Indic.* 58: 418-425)

POP LEVELS HIGHER IN MEDITERRANEAN THAN IN NORTH ATLANTIC OR SOUTHERN HEMISPHERE CETACEANS

See Table 5 for values in three species of cetacean.

(SOURCE: Pinzone, M., Budzinski, H., Tasciotti, A., Ody, D., Lepoint, G., Schnitzler, J., Scholl, G., Thomé, J.-P., Tapie, N., Eppe, G., and Das, K. 2015. POPs in free-ranging pilot whales, sperm whales and fin whales from the Mediterranean Sea: Influence of biological and ecological factors. *Environ. Res.* 142: 185-196)

Disease and mortality events

General

MASS MORTALITY OF JUVENILE AND NEWBORN HARBOUR PORPOISES IN THE BLACK SEA

The endemic harbour porpoise subspecies in the Black Sea has experienced several large-scale mortalities in the 21st century. In 2016, unusually large numbers of newborns and juveniles washed up on beaches along the Black Sea coasts of Bulgaria and Turkey (in Turkey: 7.2 individuals/km, with 150 individuals along one 22 km stretch in July alone). In total, 443 stranded cetaceans (435 of them harbour porpoises) were reported in Turkey (coastline length: 300 km), and 234 cetaceans (218 harbour porpoises) in Bulgaria (coastline length: 238 km). Most were newborns less than 70 cm long. Öztürk et al. estimate that thousands of juveniles died during this mortality event. Such successive high mortalities of young animals could be a serious impediment to the recovery of this endangered subspecies.

(SOURCES: Sanders, N. 2016. Mass mortality event of Black Sea harbour porpoises. IUCN - SSC Cetacean Specialist Group. *http://www.iucn-csg.org/index.php/2016/08/25/mass-mortality-event-of-black-sea-harbour-porpoises*; Öztürk, A.A., Tonay, A.M., Dede, A., Danyer, I., and Popov, D. 2017. Unusual mass mortality of harbour porpoises on the coast of the western Black Sea (Bulgaria and Turkey) in summer 2016. Abstract submitted to 31st European Cetacean Society Conference, Middlefart, Denmark)

STRANDING RATE OF PORPOISES CORRELATES WITH FISH STOCK DYNAMICS IN THE AZOV SEA

In 1999-2014, harbour porpoise stranding rates were regularly monitored on the southern coast of the Azov Sea, particularly at the uninhabited abraded coast of the Tarkhan Cape. Specifically, the general trends and annual fluctuations in strandings were compared to the catch reports of the Azov Sea anchovy, an important prey for porpoises. The fluctuations in stranding rates correlated with the population dynamics of the anchovy stock. A cosine function, based on the data from 1999-2012, correctly predicted maximum strandings in 2013 and their substantial decline in 2014. The function worked particularly well when biases affecting carcass preservation, such as discovery rate and drift conditions, were reduced. In certain environments and over established time periods, the cetacean stranding rate can be an indicator of population trends which may be verified by external factors, including the dynamics of prey stocks.

(SOURCE: Vishnyakova, K. and Gol'din, P. 2015. Cetacean stranding rate correlates with fish stock dynamics: Research of harbour porpoises in the Sea of Azov. *Mar. Biol.* 162: 359-366)

Harmful Algal Blooms (HABs)

FIRST GLOBAL INTEGRATED MARINE ASSESSMENT: BLACK SEA

The upper layer of water (ca. 150 m) in the Black Sea supports unique marine, freshwater, brackish and relic species (approximately 5000). The deeper layers are saturated with hydrogen sulphide and largely devoid of multi-cellular invertebrates. The eastern sector is a recognised biodiversity hotspot. A UN report identifies invasion by alien species as a key threat to the Black Sea ecosystem, with two species being of particular importance. The first is an American filter-feeding comb jelly, which has led to the collapse of pelagic fish populations (26 commercial fish stocks) and caused a major shift in the marine ecosystem (partially offset by the invasion of another, predatory comb jelly). The second is algae that produce harmful algal blooms and can further deplete the oxygen in the water. Temperature increases at the surface mixing with cold intermediate water layers have further accelerated species shifts. Critical status has been recognised for 13 out of 37 benthic habitats, including the neritic water column, coastal lagoons, estuaries and deltas. These developments, along with illegal fishing (gillnet entanglement), pose the greatest threats to the three cetacean species inhabiting the Black Sea, all of which are listed as Endangered or Vulnerable on the IUCN Red List.

(SOURCE: Inniss, L. and Simcock, A. (Joint coordinators); Rice, J. (Lead member of 14 contributors). 2016. The first global integrated marine assessment: World ocean assessment I. *United Nations, Chapter 36A:* p. 16-18. *http://www.un.org/Depts/los/global_reporting/WOA_RPROC/Chapter_36A.pdf*)

Climate change

CLIMATE CHANGE A 'DOUBLE ISSUE' IN THE MEDITERRANEAN SEA

Climate change is a particular issue for enclosed seas, where organisms cannot migrate to higher latitudes. The Mediterranean is doubly affected because it is increasingly being inhabited by (sub) tropical non-indigenous species ('tropicalisation'). Moreover, warm-water native species previously restricted to southern sectors are now establishing themselves in the colder northwest basin ('meridionalisation'). The authors report that 20 southern species have been found for the first time at Genoa, including zebra seabream, parrotfish and juvenile Indo-Pacific bluespotted cornetfish. The linear increase in the number of warm-water native species and the exponential increase in the number of non-indigenous species point to a tropicalisation (rather than a meridionalisation) even in the northern sectors of the Mediterranean basin. If the present seawater warming continues, the Mediterranean would undergo a generalised process of biotic homogenisation. Such major ecosystem changes probably ultimately affect the entire food web, including top predators such as cetaceans. The authors point to the need for sustained monitoring as "a major concern for scientists and environmental managers alike".

(SOURCE: Bianchi, C.N., Caroli, F., Guidetti, P., and Morri, C. 2018. Seawater warming at the northern reach for southern species: Gulf of Genoa, NW Mediterranean. *J. Mar. Biol. Assoc. UK* 98:1-12, doi:10.1017/S0025315417000819)

CLIMATE CHANGE COULD REDUCE COMMON DOLPHIN HABITAT IN THE ALBORÁN SEA

Short-beaked common dolphin distribution and environmental variables recorded in the Alborán Sea were used to project the impacts of climate change via changes in sea surface temperatures on dolphin habitat. The authors conclude that increasing sea surface temperatures will lead to a decrease in common dolphin habitat.

(SOURCE: Cañadas, A. and Vázquez J.A. 2017. Common dolphins in the Alborán Sea: Facing a reduction in their suitable habitat due to an increase in sea surface temperature. *Deep-Sea Res. Pt. II* 141: 306-318)

Noise impacts

VESSEL TRAFFIC ALTERS THE BEHAVIOUR OF BOTTLENOSE DOLPHINS AND HARBOUR PORPOISES IN THE ISTANBUL STRAIT

The Istanbul Strait is one of the busiest international waterways in the world. The effect of marine traffic, location and season on the behavioural transitions, behavioural budget and bout duration (average time in each behavioural state) of bottlenose dolphins was investigated and modelled. Marine vessels were the main driving force for behavioural transitions, leading to significant changes in behavioural budget and bout durations. There was a significant decrease in socialising, surface-feeding and resting behaviour in the presence of boats, whilst diving behaviour increased. Moreover, dolphins spent less time surface-feeding, resting, socialising and diving once disrupted. The current level of vessel-dolphin interaction in this area (51% of observation time) was sufficient to significantly alter the dolphins' cumulative behavioural budget. Finally, speed and distance of vessels played a considerable role in the directional responses of dolphins. The authors argue for creating protected zones in order to mitigate vessel-dolphin interactions, because the population is already classified as 'at risk' and still lacks a species-specific conservation plan. In a second study, high-speed ferries and boats were identified as the major cause of disturbance. Accordingly, the authors recommend that the proposed protected zones (three different seasonally managed areas) should limit the speed and density of marine traffic. A third study on the endangered Black Sea harbour porpoise in the strait showed similar results: vessel presence, speed and distance affected behavioural bout length and swimming direction, but there was no significant cumulative (diurnal) behavioural budget change. Nonetheless, exposure to high-speed vessels resulted in a strong response, which could lead to porpoise displacement from large areas. Porpoise density was higher in areas with less traffic (northern strait) and lower in areas of high traffic (southern and central strait). The authors argue for species-specific conservation actions, especially in the northern sections of the strait, including vessel exclusion zones, enforced speed limits and the designation of specific channels for ferries.

(SOURCES: Bas, A.A., Christiansen, F., Öztürk, B., Öztürk A.A., Erdoğan, M.A., and Watson, L.J. 2017. Marine vessels alter the behaviour of bottlenose dolphins *Tursiops truncatus* in the Istanbul Strait, Turkey. *Endang Species Res* 34:1-14; Bas A.A., Öztürk A.A., and Öztürk B. 2015. Selection of critical habitats for bottlenose dolphins (*Tursiops truncatus*) based on behavioral data, in relation to marine traffic in the Istanbul Strait, Turkey. *Mar. Mamm. Sci.* 31: 979-997; Bas, A.A., Christiansen, F., Öztürk, A.A., Öztürk, B., McIntosh, C. 2017. The effects of marine traffic on the behaviour of Black Sea harbour porpoises (*Phocoena phocoena relicta*) within the Istanbul Strait, Turkey. *PLoS ONE* 12(3): e0172970. doi:10.1371/journal.pone.0172970)

LOWER CETACEAN ABUNDANCE IN AREAS OF HIGH VESSEL TRAFFIC IN THE WESTERN MEDITERRANEAN

Shipping vessel number and cetacean abundance, determined via line transect surveys, were examined in the western Mediterranean Sea region. In locations with cetacean sightings, shipping traffic was 20% lower compared to random locations where no sightings were made. Most cetacean species, common bottlenose dolphins excepted, were observed in locations with lower levels of vessel traffic. Line transects in the Pelagos Sanctuary found reduced abundances of fin whales and striped dolphins in areas with more vessel traffic in the southeast region, and of large whales in the western portion of the sanctuary, where there is more vessel traffic. In the central part of the sanctuary - with moderate vessel traffic yet important feeding habitat locations - there were minor differences in the abundance of species (specifically Cuvier's beaked whales, sperm whales, fin whales and striped dolphins). It is possible that feeding habitats are so important that cetaceans still use these areas despite boat disturbance.

(SOURCE: Campana, I., Crosti, R., Angeletti, D., Carosso, L., David, L., Di-Méglio, N., Moulins, A., Rosso, M., Tepsich, P. and Arcangeli, A. 2015. Cetacean response to summer maritime traffic in the Western Mediterranean Sea. *Mar. Environ. Res.* 109: 1-8)

ITALY INTRODUCES MONITORING SCHEME FOR MARINE MAMMAL PRESENCE FOR SEISMIC EXPLORATION

Anthropogenic noise (e.g., naval sonar, pile driving, geophysical surveys) has now been recognised as a threat to marine fauna. Current oil and gas industry and navy protocols, as well as other guidelines based on 'best practise' or precautionary approaches for civil and industrial activities, are not standardised. In 2015, the Italian Environmental Impact Assessment Commission issued new criteria for obtaining permits for oil and gas exploration. It mandated that seismic operators apply a standardised protocol to compare the presence of marine mammals before, during and after offshore seismic surveys (see *http://www.va.minambiente.it/it-IT*). It established a 60-day monitoring period using both visual and acoustic methods. The authors underline that this approach, if used internationally, would improve the study of far-reaching intense low-frequency noise. The collected data are to be stored and made public by the Italian Ministry of the Environment.

(SOURCE: Fossati, C., Mussi, B., Tizzi, R., Pavan, G., and Pace, D.S. 2017. Italy introduces pre and post operation monitoring phases for offshore seismic exploration activities. *Mar. Pollut. Bull.* 120: 376-378, *https://doi.org/10.1016/j.marpolbul.2017.05.017*)

RESIDENT POPULATION OF BOTTLENOSE DOLPHIN AFFECTED BY VESSEL NOISE

Vessel traffic is known to affect the resident bottlenose dolphin's distribution and habitat use in the Cres-Losinj archipelago (Croatia, Adriatic Sea, a Natura 2000 site). This study found that the acoustic behaviour of the population is also affected by vessel noise. Dolphins significantly changed their whistle structure at high levels of ambient noise and in the presence of boats. These waters are visited consistently by sensitive mother-calf groups. The researchers called for an improved understanding of the overall acoustic repertoire of bottlenose dolphins and for determining potential population-level changes in the presence of these disturbance factors.

(SOURCE: Gospic, N.R. and Picciulin, M. 2016. Changes in whistle structure of resident bottlenose dolphins in relation to underwater noise and boat traffic. *Mar. Pollut. Bull*. 105: 193-198, *https://doi.org/10.1016/j.marpolbul.2016.02.030*)

UNDERWATER NOISE HOTSPOTS IN THE MEDITERRANEAN SEA AND THE EXTENT OF SEISMIC SURVEYING

A number of noise-producing activities might threaten cetaceans in the Mediterranean Sea, including coastal and offshore activities, seismic surveys, naval exercises and vessel traffic. Between 2005 and 2015, 1446 harbours, 228 oil/gas drilling platforms, 52 windfarm projects, 830 seismic exploration areas and a number of military exercise areas were identified. In July 2014, 7 million maritime vessel positions were recorded every 10 minutes. On average, there were 1500 vessels present in the area at any time, with the heaviest density of traffic in northern and western parts of the Mediterranean Sea and in Greek waters. The maximum and minimum areas where seismic surveys were being conducted were calculated: 27% of the surface of the Mediterranean (675,000 km^2) in 2013 and 3.8% (67,000 km^2) in 2005. Hotspots of underwater noise that overlapped key cetacean habitat included the Pelagos Sanctuary, the Strait of Sicily and the Hellenic Trench. The authors conclude that "these results provide strong evidence of multiple stressors acting on the marine environment and of the need for urgent management and conservation actions".

(SOURCE: Maglio, A., Pavan, G., Castellote, M., and Frey, S. 2016. *Overview of Noise Hotspots in the ACCOBAMS Area.* Report for the ACCOBAMS Secretariat)

RECOMMENDATIONS FOR REDUCING THE IMPACTS OF SEISMIC SURVEYS AND UNDERWATER NOISE IN THE EASTERN MEDITERRANEAN SEA

A workshop was held in Croatia on mitigating the impacts of underwater noise, particularly from seismic surveys, in the eastern Mediterranean Sea. The workshop was attended by 65 participants from 15 countries. Recommendations from the meeting included taking a precautionary approach to noise management; developing a 'noise budget' for eastern Mediterranean waters; considering potential cumulative or synergistic impacts on cetaceans, including the impacts of climate change; and assessing the effectiveness of mitigation measures and monitoring activities. Better communication and sharing of information was also suggested, in particular information on the distribution of sensitive species. Strategic Environmental Assessments should be conducted

by governments and analysed before any locations are licensed to the oil and gas industry. The *Convention on Migratory Species (CMS) Guidelines on Environmental Impact Assessments for Marine Noise Generating Activities* should be incorporated into national legislation and species management plans. The number of seismic surveys should be limited and their timing should be planned to avoid key periods for sensitive species. Duplication of seismic surveys should be avoided and the use and development of the best-available quieting technologies (e.g., marine vibroseis) should be pursued. The lack of training of (and capacity for) marine mammal observers and acoustic monitoring staff on seismic survey vessels should be addressed. A global report should be prepared on the best available technology and environmental practises for the mitigation of underwater anthropogenic noise, and should be made available to all government agencies in the region. Education and awareness-raising of the need to reduce noise in the marine environment was also recommended. Finally, subsidies for the oil and gas industry should be removed and public funds should be spent in line with the objectives of the 2015 Paris Agreement on Climate Change, i.e., in a way to reduce greenhouse gas emissions.

(SOURCE: NRDC, OceanCare, DBU. 2017. *Mitigating the impact of underwater noise on marine biodiversity with specific focus on seismic surveys in the south eastern European waters in the Mediterranean Sea.* Workshop held November 22-23, 2017. Split, Croatia.)

OVERLAP BETWEEN CETACEANS AND SHIPPING IN THE PELAGOS SANCTUARY

A spatial analysis was conducted of shipping and the distribution of striped and bottlenose dolphins and fin whales in the southern part of the Pelagos Sanctuary. Overlap with vessel traffic occurred for all three species, with the greatest degree of overlap for striped dolphins, followed by bottlenose dolphins, then fin whales. Importantly, despite their lower overlap with shipping, fin whales might be particularly vulnerable to this source of disturbance because the overlap was associated with productive feeding areas, and animals focusing on feeding might be less reactive to approaching vessels.

(SOURCE: Pennino, M.G., Arcangeli, A., Prado Fonseca, V., Campana, I., Pierce, G.J., Rotta, A., and Bellido, J.M. 2017 A spatially explicit risk assessment approach: Cetaceans and marine traffic in the Pelagos Sanctuary (Mediterranean Sea). *PLoS ONE* 12(6): e0179686, *https://doi.org/10.1371/journal.pone.0179686*)

FIN WHALES SILENT WHEN SEISMIC SURVEY NOISE DETECTED IN THE IONIAN SEA

Acoustic recordings made in the Ionian Sea detected 20 Hz calls from fin whales and pulses from seismic survey airguns. Airgun pulses were recorded in four of the 10 analysed months and occurred daily between 25 November 2012 and 21 February 2013 - this period coincided with an absence of recorded fin whale calls. The daily airgun pulses led to an increase in low frequency background noise (below 50 Hz) of 10 dB. The received levels of airgun pulse noise indicated that the sound originated several hundreds of kilometres from the recording site. This suggests a significant impact from seismic surveys on fin whale vocalisations in this area.

(SOURCE: Sciacca, V., Viola, S., Pulvirenti, S., Riccobene, G., Caruso, F., De Domenico, E. and Pavan, G. 2017. Shipping noise and seismic airgun surveys in the Ionian Sea: Potential impact on Mediterranean fin whale. *Proceed. Mtgs Acoust.* 27, 040010: 1-10, *https://doi.org/10.1121/2.0000311*)

THE POTENTIAL IMPACT OF SEISMIC SURVEYS IN THE MEDITERRANEAN SEA

This review assessed sources of underwater noise that might pose a problem for cetaceans in the Mediterranean Sea. Potential sources included: (a) shipping traffic; (b) military exercises; (c) seismic surveys; (d) development projects, both coastal and offshore; and (e) marine tourism. Over the past 10 years, seismic surveys have increased in the southeast Mediterranean, especially in the Adriatic Sea and the Hellenic Trench. Concern about the impacts of underwater noise extends also to essential prey species such as zooplankton. However, the author notes that "the full extent of the impact of seismic surveys at the population level is mostly unknown, partially due to the lack of baseline knowledge about the abundance and distribution of [cetaceans]". A number of mitigation measures was recommended, including: (a) improved cetacean surveys; (b) the establishment of strandings detection programmes; (c) more research on the impacts of seismic surveys; (d) no-go zones for seismic surveys; (e) increased capacity in Mediterranean nations to conduct effective environmental impact assessments; (f) the use of new technologies, such as marine vibroseis; (g) better funding and training (e.g., for marine mammal observers on seismic survey vessels); and (h) improved communication amongst stakeholders.

(SOURCE: Štrbenac, A. 2017. *Overview of Underwater Anthropogenic Noise, Impacts on Marine Biodiversity and Mitigation Measures in the South-Eastern European Part of the Mediterranean, Focussing on Seismic Surveys*. Report from Stenella Consulting, Croatia, for OceanCare, Switzerland)

COMPARING MONITORED AND MODELLED NOISE LEVELS IN ITALIAN WATERS AS A STRATEGY FOR PLANNING FUTURE SHIPPING TRAFFIC ROUTES

Acoustic noise levels were measured in waters off Sicily and compared with the results of a model based on AIS data. The hydrophones were installed at a depth of over 2000 m, 25 km off Catania, Sicily. The measured values correlated well with the passage of ships tracked by AIS. This monitoring was requested by the EU Directive on Marine Strategy in an effort to achieve 'Good Environmental Status'. The data are essential in planning new routes for shipping traffic (as anticipated for the future 'European Motorways of the Sea'). They will also be helpful in elaborating mitigation measures for protected species that could be threatened by high noise levels at low frequencies; e.g., fin whales. Comparing noise distribution with animal density will help identify noise hotspots for the most sensitive species.

(SOURCE: Viola, S., Grammauta, R., Sciacca, V., Bellia, G., Beranzoli, L., Buscaino, G., Caruso, F., Chierici, F., Cuttone, G. D'Amico, A., De Luca, V., Embriaco, D., Favali, P., Giovanetti, G., Marinaro, G., Mazzola, S., Filiciotto, F., Pavan, G., Pellegrino, C.,

Pulvirenti, S., Simeone, F., Speziale, F., and Riccobene, G. 2017. Continuous monitoring of noise levels in the Gulf of Catania (Ionian Sea). Study of correlation with ship traffic. *Mar. Pollut. Bull.* 121: 97-103, *https://doi.org/10.1016/j.marpolbul.2017.05.040*)

GLOBAL

General

MONITORING WHALE HEALTH VIA DRONES

A small hexacopter drone was used to collect the blow from humpback whales off the east coast of the USA. Genetic analysis of the blow samples allowed identification of an array of microbes, identifying the normal microbial flora of the whale respiratory tract. No known respiratory pathogens were detected. This new technique allows the non-invasive monitoring of the respiratory health of whales.

(SOURCE: Apprill, A., Miller, C.A., Moore, M.J., Durban, J.W., Fearnbach, H., and Barrett-Lennard, L.G. 2017. Extensive core microbiome in drone-captured whale blow supports a framework for health monitoring. *mSystems* 2: e00119-17, *https://doi.org/10.1128/mSystems.00119-17*)

GLOBAL THREAT MAPS FOR MARINE MAMMALS

More than 1780 publications (published between 1991 and 2016) were reviewed to determine the threats to 121 marine mammal species. From these data, risk maps were produced and compared with mapped distributions of marine mammals. Almost all species were reported to be facing at least one threat. Bycatch had the greatest impact for the most species (112 species), followed by pollution (99 species), direct harvesting (89 species) and ship strikes (86 species). Threats such as urban development, tourism, directed catches and fishing affected more than 60 species. Threats were associated with more than 51% of marine mammal core habitat. Particular threat hotspots included the coastal waters of temperate and polar areas, notably the Baltic and Mediterranean Seas. Risk patterns for odontocetes and mysticetes were similar, with high-risk areas for both being concentrated on the east coasts of North America and Asia, with additional risk zones for mysticetes off the west coast of South America and off southern Australia. Humpback and sperm whales were exposed to the greatest area of risk, and common bottlenose dolphins were exposed to the highest diversity of risks. Species with restricted distributions had the greatest risks with respect to the proportion of their core habitat affected (e.g., Hector's, Heaviside's and Chilean dolphins, vaquita, franciscana and gray and North Atlantic right whales). The authors note that "human activities in coastal waters worldwide impose previously unrecognised levels of cumulative risk for most of marine mammal species". They also suggest that these risk maps might be useful for planning marine protected areas for marine mammals.

(SOURCE: Avila, I.C., Kaschner, K. and Dormann, C.F. 2018. Current global risks to marine mammals: Taking stock of the threats. *Biol. Conserv.* 221: 44-58)

ENVIRONMENTAL CHANGES AND ANTHROPOGENIC DISTURBANCE COULD HAVE SIGNIFICANT POPULATION-LEVEL EFFECTS

A model was constructed to investigate the effects of environmental changes and anthropogenic disturbances on the energetics of blue whales in the eastern North Pacific. The model predicted that unprecedented environmental changes (such as in 2005, when the annual California Current-induced upwelling was delayed by several months) affecting female reproductive success will cause a decline in recruitment rates (dropping from 95% to 69%), with reproductive failures increasing (aborted calf rate will increase from 2% to 26%). Modelling intense local disturbances (such as an exercise using naval sonar, seismic surveys or similar) revealed that if whales stayed in the disturbed location, the abortion rate for calves rose to 12.5% and the proportion of calves starving rose to 18.5%, with the recruitment rate dropping to 63%. Modelling a widespread but weak level of disturbance (such as from whale watching or shipping traffic) showed a small drop in recruitment rate (to 94%), partly because of a calf starvation rate of 0.2%, on average. This modelling exercise demonstrates the significant effect major environmental changes (from climate change, for example) or intense anthropogenic disturbances could have on threatened whale populations.

(SOURCE: Pirotta, E., Mangel, M., Costa, D.P., Mate, B., Goldbogen, J.A., Palacios, D.M., Hückstädt, L.A., McHuron, E.A., Schwarz, L., and New, L. 2018. A dynamic state model of migratory behavior and physiology to assess the consequences of environmental variation and anthropogenic disturbance on marine vertebrates. *Am. Nat.* 191(2): E40-E56, *https://doi.org/10.1086/695135*)

Habitat degradation

General

LANDMARK CONVENTION ON BALLAST WATER ENTERED INTO FORCE IN 2017

The IMO has crafted a convention that requires ships to manage their ballast water to remove, render harmless or avoid the uptake or discharge of aquatic organisms and pathogens with ballast water and sediment. The goal is to avoid the spread of invasive species, which is threatening "the ecological and economic well-being of the planet". These clear and robust new standards require all ships to carry a ballast water record book and an International Ballast Water Management Certificate. Most ships will have to install onboard systems to treat ballast water and eliminate unwanted organisms. The entry into force involved ratification by 30 States (total 52 contracting Parties), representing 35% of world merchant shipping tonnage. This is an important step forward in checking the spread of, amongst others, harmful algae that cause mass mortalities of marine organisms (e.g., fish kills), promote oxygen depletion, and affect all levels of the food chain, including cetaceans.

(SOURCE: The Maritime Executive. Ballast water convention to enter into force in 2017, *https://www.maritime-executive.com/article/ballast-water-convention-to-enter-into-force-in-2017#gs.nb0nIE8*)

Fisheries interactions

FISHERIES DISCARDS REMAIN A GOBAL ISSUE

A global marine fisheries bycatch reconstruction project estimated that fish discarded by commercial fisheries peaked at 18.8 million tons in 1989, declining afterward to current levels of less than 10 million tons/year. Most discards were generated by industrial (i.e., large-scale) fisheries. More recently, fleets operating in northwest Pacific and western central Pacific waters have generated the most discards (reflecting a shift from Atlantic waters). The fact that essentially marketable species are involved suggests "a combination of poor fishing practices and poor management procedures". The discards amount to approximately 10% of the world's marine fishery catches, pointing to a major, wasteful exploitation that potentially affects the entire marine ecosystem, including top predators such as cetaceans.

(SOURCE: Zeller, D., Cashion, T., Palomares, M., and Pauly, D. 2017. Global marine fisheries discards: A synthesis of reconstructed data. *Fish and Fisheries* 19: 30-39, *https://doi.org/10.1111/faf.12233*)

Marine Debris

MARINE DEBRIS RECOGNISED AND ADDRESSED BY HIGHEST INTERNATIONAL ORGANISATION

Marine debris has been recognised as a crucial issue by the UN Environment Assembly, which seeks by 2025 to "prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and microplastics". The recent actions related to this 'Sustainable Development Goal 14' include a 2017 commitment by Member States to the 'Our Ocean, Our Future: Call for Action' declaration, as well as the 'Group of 20 Action Plan on Marine Litter', also adopted in 2017. The UN Environment Assembly has, amongst eight other points of action, invited the "relevant international and national organizations and conventions…to increase their action to prevent and reduce marine litter and microplastics and their harmful effects and to coordinate where appropriate to achieve that end". The first meeting of the Ad Hoc Open-Ended Expert Group on Marine Litter and Microplastics will be held in late May 2018 in Nairobi, Kenya, and the ministers of all Member States are invited to submit position papers.

(SOURCE: Marine litter and microplastics. United Nations. UNEP/EA.3/Res.7. 2018)

Disease and mortality events

Harmful Algal Blooms (HABs)

TOXIC ALGAL BLOOMS ON THE RISE IN NORTHERN HEMISPHERE

High-resolution sea-surface temperature records over the last three decades were used to model the trends in HABs in the North Atlantic and North Pacific Oceans. The model shows that increasing ocean temperatures have facilitated the expansion of two harmful dinoflagellates, *Alexandrium fundyense*, which produces saxitoxin (causing paralytic shellfish poison in humans) and *Dinophysis acuminata*, which produces okadaic acid (causing diarrheic shellfish poisoning in humans). The temperature effect meant increased growth rates of these organisms and increased durations of HAB events (bloom season). Beyond the human health threat, HABs also affect ecosystems (e.g., fish kills) and cetaceans. The authors predict that continued ocean warming will "promote the intensification and redistribution of these, and likely other HABs, around the world".

(SOURCE: Gobler, C.J., Doherty, O.M., Hattenrath-Lehmann, T.K., Griffith, A.W., Kang, Y., and Litaker, R.W. 2017. Ocean warming since 1982 has expanded the niche of toxic algal blooms in the North Atlantic and North Pacific Oceans. *PNAS*. 201619575, *https://doi.org/10.1073/pnas.1619575114*)

Oil spills

IMMUNE SYSTEM RESPONSES IN DOLPHINS EXPOSED TO THE DEEPWATER HORIZON (DWH) OIL SPILL

To investigate the effect of the DWH oil spill on living common bottlenose dolphins in Barataria Bay, Louisiana, blood samples were analysed from live-captured animals. Potentially oil-exposed animals demonstrated an increase in T white blood cells (in 2011) and B white blood cells (in 2011 and 2013). Certain cytokine levels were notably different from levels in a control population (and perhaps indicative of bacterial infections by pathogens such as *Brucella* - one of the pathogens that was implicated in the high rate of young dolphin mortalities post-oil spill). The white blood cell responses were similar to "those documented in other species following exposure to oil or [polyaromatic hydrocarbons] and were most pronounced in [Barataria Bay in] 2011, at the place and time most affected by oil".

(SOURCE: De Guise, S., Levin, M., Gebhard, E., Jasperse, L., Hart, L.B., Smith, C.R., Venn-Watson, S., Townsend, F., Wells, R., Balmer, B., Zolman, E., Rowles, T., and Schwacke, L. 2017. Changes in immune functions in bottlenose dolphins in the northern Gulf of Mexico associated with the *Deepwater Horizon* oil spill. *Endanger. Species Res.* 33: 291-303)

OIL-DISPERSANT MIX CAUSES DOLPHIN WHITE BLOOD CELL SUPPRESSION

The immunotoxicity of the oil released in the DWH oil spill and the chemical dispersant Corexit was examined by investigating dolphin white blood cell responses to exposure *in vitro*. Oil exposure caused a proliferation of white (T and B) blood cells, but exposure to the oil mixed with the dispersant led to a decrease. The authors conclude that "The immunosuppression of [lymphocyte cells] at environmentally relevant concentrations of oil and dispersant suggests that marine mammals may be unable to mount an adequate defence against xenobiotic threats following exposure to oil and dispersant, leaving them more susceptible to disease".

(SOURCE: White, N.A., Godard-Codding, C., Webb, S.J., Bossart, G.D. and Fair, P.A. 2017. Immunotoxic effects of in vitro exposure of dolphin lymphocytes to Louisiana sweet crude oil and Corexit™. *J. Appl. Toxicol.* 37: 676-682)

Climate change

COLLAPSE OF THE WEST ANTARCTIC ICE SHEET MIGHT BE INEVITABLE

As a result of climate change-related melting, warm seawater inundation underneath the ice sheet and shearing stresses, there are concerns that the Western Antarctic Ice Sheet will collapse. Satellite images indicate that there is currently a high level of seawater undermining the ice sheet, increasing this likelihood. At present, most moderate (and worst-case) climate change models predict the collapse of the ice sheet. This could lead to a 20 cm rise in sea level per decade by 2100, in addition to major associated Antarctic ecosystem changes.

(SOURCE: Hulbe. C. 2017. Is ice sheet collapse in West Antarctica unstoppable? *Science* 356: 910-911)

CLIMATE CHANGE-INDUCED REDUCTION IN KRILL BIOMASS PREDICTED

A study estimating the effects of ocean warming on krill biomass in the Scotia Sea (the northern part of the Antarctic Peninsula and adjacent areas to the northeast) noted considerable declines. In particular, krill biomass in the northern Scotia Sea could potentially decline by 40%. This would likely have impacts on Antarctic predators - for example, a decline in penguin abundance of 30% was predicted, and there was a high risk of these animals becoming depleted. The study also noted that if current krill fishing ceased immediately, the impacts on the krill population could be mitigated. Although in this model the impacts on mysticetes were slight in this particular region (there was an impact upon pinnipeds), this study nonetheless does project a decline in krill biomass and ecosystem change in at least part of the Southern Ocean because of climate change. This calls for an investigation of the impacts of krill biomass reduction in regions more critical for mysticetes.

(SOURCE: Klein, E.S., Hill, S.L., Hinke, J.T., Phillips, T., and Watters, G.M. 2018. Impacts of rising sea temperature on krill increase risks for predators in the Scotia Sea. *PLoS ONE* 13(1): e0191011, 1-21)

MAJOR DECREASE IN BIOLOGICAL PRODUCTIVITY PREDICTED DUE TO CLIMATE CHANGE

A new study predicted that fish populations may decline by as much as 20% globally and 60% in the North Atlantic due to a decline in ocean mixing, a result of climate change. The model assumes a 'business-as-usual' scenario, i.e., carbon emissions continue at the same rate as present. In particular, a combination of changing winds and warmer upper waters in the Southern Ocean will cause more nutrients to sink into the deeper layer of the ocean and become trapped there, substantially decreasing the productivity of Antarctic waters. The authors suggest that these changes could mean that fisheries will be reduced for a thousand years or more. This will have major impacts on the prey base of cetaceans.

(SOURCE: Moore, J.K., Fu, W., Primeau, F., Britten, G.L., Lindsay, K., Long, M., Doney, S.C., Mahowald, N., Hoffman, F., and Randerson, J.T. 2018. Sustained climate warming drives declining marine biological productivity. *Science* 359: 1139-1143)

RECORD LEVELS OF ATMOSPHERIC CARBON DIOXIDE LEVELS RECORDED

Atmospheric carbon dioxide levels exceeded 410 ppm in March 2018, the highest levels ever recorded in human history. Predicted levels in carbon dioxide will likely exceed 412 ppm in May 2018, which is 47% higher than pre-industrial carbon dioxide levels.

(SOURCE: Scripps Institution of Oceanography. 2018. The Keeling curve. *https://scripps.ucsd.edu/programs/keelingcurve*)

CLIMATE CHANGE PREDICTED TO INCREASE NUTRIENT POLLUTION

Nutrient pollution (which in turn would result in ecosystem degradation and oxygen-deprived 'dead zones') is predicted to increase due to climate change-induced precipitation (which could increase nutrients in river systems by approximately 19% in the USA alone). To prevent this, the amount of nitrogen input into the environment (e.g., via fertilisers) would have to be reduced by a third (thereby affecting food production). In particular, greater precipitation will increase nutrient pollution in the waters of India, China and southeast Asia.

(SOURCE: Sinha, E., Michalak, A.M., and Balaji, V. 2017. Eutrophication will increase during the 21st century as a result of precipitation changes. *Science* 357: 405-408)

Noise impacts

BEAKED WHALES RESPOND TO MID-FREQUENCY SONAR UP TO 100 KM AWAY

The behaviour of tagged Cuvier's beaked whales was observed in response to mid-frequency military sonar exposure during naval exercises off the coast of southern California. During sonar-exposed deep dives, subsequent shallow dives and surface intervals were longer than normal. The longer interval between deep dives suggested disrupted foraging. Longer deep (foraging) dive intervals were noted even when the sonar sources were approximately 100 km away.

(SOURCE: Falcone, E.A., Schorr, G.S., Watwood, S.L., DeRuiter, S.L., Zerbini, A.N., Andrews, R.D., Morrissey, R.P. and Moretti, D.J. 2017 Diving behaviour of Cuvier's beaked whales exposed to two types of military sonar. *Roy. Soc. Open Sci.* 4: 170629, 1-21)

HARBOUR PORPOISES RESPOND WHEN EXPOSED TO A SINGLE SEISMIC AIRGUN

Tagged harbour porpoises were exposed to a single seismic airgun for one minute (at a distance of 0.42-0.69 km and sound exposure levels of 135-147 dB re 1 μPa^2) and their reactions recorded. Two animals demonstrated shorter and shallower dives (normal behaviour resumed after 17 hours) and one animal rapidly swam away from the sound source (normal diving/swimming behaviour resumed after 35 hours), avoiding the area of the sound source for six days. This study demonstrates a significant behavioural reaction by harbour porpoises to just a single seismic airgun (seismic surveys typically have an array of many airguns).

(SOURCE: van Beest, F.M., Teilmann, J., Hermannsen, L., Galatius, A., Mikkelsen, L., Sveegaard, S., Balle, J.D., Dietz, R., and Nabe-Nielsen, J. 2018 Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun. *Roy. Soc. Open Sci.* 5: 170110, 1-14, *http://dx.doi.org/10.1098/rsos.170110*)

'RAMP-UP' MAY NOT BE AN EFFECTIVE MITIGATION MEASURE FOR PROTECTING CETACEANS FROM MILITARY SONAR

'Ramp-up' or 'soft start', a gradual increase in volume of an intense anthropogenic sound source, is a frequently touted mitigation measure for intense sound-producing activities, such as seismic surveys or military sonar exercises. The assumption is that the initial low sound level will warn cetaceans that there will be an acoustic event, so that they can move out of the area of impact. However, only a few studies have tested whether this indeed occurs. A study on the reaction of a tagged humpback whale to a ramp-up of mid-frequency sonar (1.3-2.0 kHz) found that there was some response to the ramped-up signal, but the whale was at times unresponsive to the low levels of sound during the soft start. It was suggested that naïve, non-feeding or more skittish animals (such as mothers with calves) might react more readily to the initial low levels of sound, making this method more effective for these classes of animals. Overall, however, "ramp-up may not be effective" as a mitigation measure for intense sound activities.

(SOURCE: Wensveen, P.J., Kvadsheim, P.H., Lam, F.-P. A., von Benda-Beckmann, A.M., Sivle, L.D., Visser, F., Curé, C., Tyack, P.L., and Miller, P.J.O. 2017. Lack of behavioural responses of humpback whales (*Megaptera novaeangliae*) indicate limited effectiveness of sonar mitigation. *J. Exp. Biol.* 220: 4150-4161. doi:10.1242/jeb.161232)

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Appendix 1

GLOSSARY

Species glossary

Blue whale	*Balaenoptera musculus*
Chilean dolphin	*Cephalorhynchus eutropia*
Common bottlenose dolphin	*Tursiops truncatus*
Common bottlenose dolphin (Black Sea)	*Tursiops truncatus ponticus*
Cuvier's beaked whale	*Ziphius cavirostris*
Fin whale	*Balaenoptera physalus*
Franciscana	*Pontoporia blainvillei*
Gray whale	*Eschrichtius robustus*
Harbour porpoise	*Phocoena phocoena*
Harbour porpoise (Black Sea)	*Phocoena phocoena relicta*
Heaviside's dolphin	*Cephalorhynchus heavisidii*
Hector's dolphin	*Cephalorhynchus hectori*
Humpback whale	*Megaptera novaeangliae*
Killer whale	*Orcinus orca*
Long-finned pilot whale	*Globicephala melas*
North Atlantic right whale	*Eubalaena glacialis*
Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Short-beaked common dolphin	*Delphinus delphis*
Sperm whale	*Physeter macrocephalus*
Spinner dolphin	*Stenella longirostris*
Striped dolphin	*Stenella coeruleoalba*
Vaquita	*Phocoena sinus*
Leatherback sea turtle	*Dermochelys coriacea*
Loggerhead sea turtle	*Caretta caretta*
Annular seabream	*Diplodis annularis*
Black Sea (Azov Sea) anchovy	*Engraulis encrasicolus*
Black Sea shad	*Alosa maeotica*
Black Sea turbot	*Scophthalmus maeoticus*
Common Pandora	*Pagellus erythrinus*
European hake	*Merluccius merluccius*

European sturgeon	*Huso huso*
Indo-Pacific bluespotted cornetfish	*Fistularia commersonii*
Lesser spotted dogfish	*Scyliorhinus canicula*
Parrotfish	*Sparisoma cretense*
Red mullet	*Mullus barbatus*
Turbot	*Psetta maeotica*
Zebra seabream	*Diplodus cervinus*
Antarctic krill	*Euphausia superba*
Comb jelly (filter-feeding)	*Mnemiopsis leidyi*
Comb jelly (predatory)	*Beroe ovata*

Heavy metals

Al – Aluminium
As – Arsenic
Cd – Cadmium
Cr – Chromium
Cu – Copper
Fe – Iron
Hg – Mercury
Mn – Manganese
Mo – Molybdenum
Ni – Nickel
Pb – Lead
Se – Selenium
Sn –Tin
V – Vanadium
Zn – Zinc

Glossary of terms

Abraded: Abrasion is the mechanical scraping of a rock surface by friction between rocks and moving particles during their transport by wind, glacier, waves, gravity, running water or erosion. An abraded coastline is formed by this action.

ACCOBAMS: Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area.

AIS: Automatic Identification System (automatic vessel-tracking system).

Benthic: Referring to the ocean bottom.

Bifenthrin: An insecticide in the pyrethroid family. It is highly toxic to aquatic organisms.

Bioaccumulation: Increase in concentration of a pollutant within an organism compared to background levels in its diet.

Biomagnification: Increase in concentration of a contaminant from one link in a food chain to another.

Biomarker: A biological indicator, e.g., blood chemical levels, of health status or pollutant level.

Biomonitor: Species used to track toxic chemical compounds, elements or their metabolites in the environment. These compounds are typically measured in the biomonitor's blood and urine.

Biosphere Reserves: Areas comprising terrestrial, marine and coastal ecosystems that promote solutions reconciling the conservation of biodiversity with its sustainable use, managed by UNESCO.

Bivalve: An aquatic mollusc with a flattened body enclosed by a hinged shell, e.g., clam, oyster.

Bottom otter trawls: A form of bottom trawl net that 'ploughs' up to 15 cm into the sea floor, using flat boards ('otter boards') to keep the mouth of the net open.

Brucella: Various species of bacteria that cause the disease brucellosis.

CBD Aichi Target: The Conservation on Biological Diversity's biodiversity targets, as determined at the Tenth Conference of the Parties in 2010, in Nagoya, Japan (Aichi Prefecture) - see *https://www.cbd.int/sp/targets/*

Comb jelly: A free-swimming representative of the invertebrate phylum Ctenophora.

CYP1A1: Also referred to as cytochrome P450 1A, a gene whose expression serves as a biomarker for plastics exposure.

CYP2B: Also referred to as cytochrome P450 2B, a gene whose expression serves as a biomarker for plastics exposure.

Cyhalothrin: An insecticide in the pyrethroid family.

Cytokine: Any of a number of substances, such as interferon, interleukin, and growth factors, that are secreted by certain cells of the immune system and have an effect on other cells.

dB: Decibel – a logarithmic measure of sound pressure level.

DDD: The organochlorine pesticide dichlorodiphenyldichloroethane, a breakdown product of DDT.

DDE: The organochlorine dichlorodiphenyldichloroethylene, a breakdown product of DDT.

DDT: The organochlorine pesticide dichlorodiphenyltrichloroethane, which tends to accumulate in the ecosystem and in the blubber and certain internal organs of cetaceans.

Deltamethrin: An insecticide in the pyrethroid family.

Dinoflagellate: A large group of unicellular algae belonging to the phytoplankton.

Dioxin: Toxic organic chemicals that can accumulate in the blubber of cetaceans. These chemicals are carcinogenic and can cause reproductive defects.

DMV: Dolphin morbillivirus

Endemic: Native or restricted to a certain country, area or region.

Endocrine disruptor: The endocrine system is a system of ductless glands producing hormones that control and moderate metabolic processes in the body. Chemicals that mimic these hormones or otherwise interfere with their activity are known as endocrine disruptors.

Epizootic: A disease outbreak in non-human animals, equivalent to an epidemic in human populations.

Eutrophication: Input of nutrients into an aquatic system, typically associated with excessive plant growth and oxygen depletion.

FAO: Food and Agriculture Organization, an intergovernmental organization with 194 Member Nations.

Gyre: Large system of rotating ocean currents.

HBCD: Hexabromocyclododecane, a brominated flame retardant.

HCB: Hexachlorobenzene, an organochloride compound.

HCH: Hexachlorocyclohexane, a polyhalogenated compound.

Hexacopter: An unmanned helicopter (drone) with six rotors.

Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1000 Hertz).

IMO: International Maritime Organisation.

IUCN: International Union for Conservation of Nature.

Lipid weight: A basis of measurement whereby concentrations of a substance are compared to the lipid (fat) content of a material.

LPO: Lipid peroxidation, the oxidative degradation of lipids. It is the process in which free radicals 'steal' electrons from the lipids in cell membranes, resulting in cell damage.

Lymphocyte cells: Small white blood cells that play a large role in defending the body against disease. Lymphocytes are responsible for immune responses. There are two main types of lymphocytes, B cells and T cells.

µg: Microgram

µPa: Micropascal, a unit of pressure.

MEHP: Monoethylhexylphthalate, a metabolite of the most common phthalate in the environment.

Meningoencephalitis: Inflammation of the membranes of the brain and the adjoining cerebral tissue.

Microplastics: Plastic particles 0.3-5 mm in diameter, often the result of larger plastic pieces breaking down over time.

Morbillivirus: A family of viruses that are typically highly infectious and pathogenic - the family includes measles, dog distemper and dolphin morbillivirus. A number of cetacean mass mortality events have been associated with viruses from this family.

MPA: Marine Protected Area.

Natura 2000: A network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types that are protected in their own right, under the European Commission.

Neritic: Relating to the shallow part of the sea near a coast and overlying the continental shelf.

nmol: Nanomole (equivalent to 10^{-9} moles).

OC: Organochlorine compound.

Organochlorine: Organic compound that contains chlorine. Many are toxic and used as pesticides. Most of these compounds persist in the environment (are not biodegradable) and also tend to accumulate in fatty tissue (e.g., blubber) of cetaceans and other marine organisms.

Ortho and non-ortho PCBs: Chemical variants of PCBs, relating to their toxicity.

PBDE: Polybrominated diphenyl ether.

PCB: Polychlorinated biphenyl.

PCDDs: Polychlorinated dibenzo-p-dioxins.

PCDFs: Polychlorinated dibenzofurans

Permethrin: An insecticide (and skin medication for scabies and lice) in the pyrethroid family.

Phthalate: A class of substances added to plastics to increase their flexibility, transparency, durability, and longevity.

Polyaromatic hydrocarbons: Organic compounds containing only carbon and hydrogen, composed of multiple aromatic rings (organic rings in which the electrons are delocalized), found in coal and tar deposits.

Polyethylene: The most common form of plastic.

POPs: Persistent organic pollutants, organic compounds that are resistant to degradation and thus persist in the environment.

pmol: Picomole (equivalent to 10^{-12} moles).

ppm: Parts per million

Pyrethroid: An organic compound similar to the natural pyrethrins produced by flowers. Pyrethroids constitute the majority of commercial household insecticides.

Ramsar: The Convention on Wetlands (also known as the Ramsar Convention).

Relic species: A species more widespread or numerous in the past.
TBARS: Thiobarbituric acid reactive substances. The TBARS assay is one of the oldest laboratory measures of oxidative stress in serum or tissues. The assay measures the concentration of malondialdehyde produced due to degradation of unstable lipid peroxides.
TEQ: Toxic equivalent.
Tetramethrin: An insecticide in the pyrethroid family.
UN: United Nations.
UNESCO: United Nations Education, Scientific and Cultural Organization.
WHO: World Health Organisation.
Xenobiotic: Of or relating to substances, typically synthetic, that are foreign to the body or ecosystem.
Zooplankton: Free-floating marine animals.

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Table 1. Mean (± SD) values of plastics biomarkers and organochlorines in sampled fin whales. (Units: CYP1A1 = pmol/mg protein; CYP2B = pmol/mg protein; LPO = nmol TBARS/mg protein; MEHP = ng/g f.w.; HCB = ng/g l.b.; DDT = ng/g l.b.; PCB = ng/g l.b.; OC = ng/g l.b.)

	N	CYP1A1	CYP2B	LPO	MEHP	HCB	ΣDDT	ΣPCBs	ΣOC
Mediterranean	30	71.9 ± 25.9	41.5 ± 22.9	11.0 ± 6.4	54.8 ± 27.7	29.9 ± 12.0	10480 ± 7480	13330 ± 8550	23830 ± 15060
Gulf of California	10	61.4 ± 28.4	52.9 ± 23.4	6.7 ± 3.8	40.0 ± 23.2	38.5 ± 33.6	3110 ± 2250	8754 ± 6540	11900 ± 6760

Table 2. Maximum insecticide pyrethroid values in the livers of striped dolphins from the Alborán Sea (µg/kg lipid weight)

Tetramethrin	Bifenthrin	Cyhalothrin	Permethrin	Deltamethrin	ΣPyrethroid
3400	36	18	1800	78	5200

Table 3. Maximum PCB levels (ΣPCB mg/kg lipid**)**

Bottlenose dolphin		Striped dolphin	Killer whale
Strait of Gibraltar	Western Mediterranean	Western Mediterranean	Strait of Gibraltar
879.3	601.39	2668.64	857.92

Table 4. Maximum trace element values recorded in cetaceans from the Mediterranean (mg/kg wet weight). Mercury levels in bottlenose dolphins were extremely high, although exceeded by levels in the Mediterranean and Adriatic Seas.

		n		Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
Sperm whale	Italian coast, Adriatic Sea	3	Brain	2.73	0.73	0.06	0.02	3.35	56.57		0.56	0.02	0.04		9.14	0.23	0.02	16.5
			Muscle	7.05	5.54	0.03	0.05	0.56	198.2		1.02	0.01	0.03		3.10	0.01	0.06	48.5
			Liver	2.79	6.71	2.84	0.12	7.62	1554		1.16	0.30	0.17		94.0	0.60	0.03	53.5
			Kidney	11.36	1.75	2.60	0.14	1.97	235.6		1.48	0.03	0.06		6.40	0.18	0.05	13.5
Bottlenose dolphin	Portuguese coast, entrance of the Mediterranean	10	Muscle		2.72	0.31		3.46		3.14	4.65		1.93	0.22	2.03			24.2
			Liver		0.94	0.47		30.6		208	4.68		0.27	0.26	117			94.9
			Kidney		1.58	2.81		8.28		40.1	1.48		0.21	0.11	11.9			46.9

Table 5. Persistent organic pollutants detected in Mediterranean cetaceans. Pollutant levels were higher than comparative populations in the North Atlantic and southern hemisphere. The levels of organic contaminants frequently exceeded an estimated 17 mg/kg lipid weight toxicity threshold.

		Contaminant concentrations in mg/kg lipid weight									Contaminant concentrations in µg/kg lipid weight				
	n	ΣPCBs	ΣICES7	ΣPBDE	DDE	DDD	DDT	ΣDDT	ΣHCH	HBCD	ΣPCDD	ΣPCDF	Σnon-ortho PCB	Σortho PCB	WHO-TEQ/g lipid weight
Long-finned pilot whale	49	103	68	1.76	165	6.09	3.86	185	0.095	0.401	0.12	0.3	3.7	3627	472
Sperm whale	43	68.5	45.9	0.78	147	7.63	9.77	170	0.33	0.214	0.13	0/74	12.0	4735	1833
Fin whale	70	25.07	17.98	1.19	19.2	2.32	0.80	26.70		0.043					