nature sustainability

Supplementary information https://doi.org/10.1038/s41893-025-01631-8

Identifying and closing gaps in corporate reporting of ocean impacts

In the format provided by the authors and unedited

Table of contents

Supplementary Table 1. Examples of sources of impact for core industries of the ocean economy.

	Cruise tourism	Marine equipment and construction	Offshore oil and gas	Offshore wind	Port activities	Seafood	Shipbuilding and repair	Shipping
Energy utilization	• Fuel consumption • Shoreside power	• Fuel consumption • Construction	• Extraction and burning of fossil fuels • Fuel consumption	• Construction • Service vessels • Power stations	• Equipment to handle goods in ports • Shoreside power	• Fuel consumption • Power generation for infrastructure • Feed production	• Power generation for equipment • Raw material manufacturing	• Fuel consumption • Shoreside power
Oil spills and gas leaks	• Vessel oil spills • Oil leakages • Methane leakages	• Fuel leaks • Equipment failure	• Oil spills and gas leaks at various stages of the production	• Turbine oil leaks	• Storage tanks • Loading and unloading oil tankers	• Fuel leaks • Equipment failure	• Oil releases during fitting operations	• Vessel oil spills • Tanker oil leaks • Wrecked ships
Pollution	• Hull discharges • Solid wastes • Oily waste discharges • Wastewater • Antifouling coatings • Light pollution	• Hazardous wastes • Antifouling coatings	• Toxic drilling mud • Drill cuttings • Produced water (mixture of water containing heavy metals, radium isotopes and hydrocarbons)	• Metal pollution from corrosion	• Solid and liquid waste (e.g., hazardous materials, packaging, oily waste) • Antifouling coatings • Stormwater runoff	• Abandoned, lost, and discarded gear • Nutrient pollution • Excess use of pesticides and antibiotics • Diseases and parasites	• Chemicals and wastes from cleaning, repair, and painting (e.g., metal scraps, paint residues) • Discharge of hazardous contaminants • Antifoulants	• Litter and sewage discharges • Cargo losses • Antifouling coatings • Chemical spills
End-of-life	• Shipbreaking	• Shipbreaking • Decommissioning of equipment	• Decommissioning (e.g., rigs, platforms, pipelines)	• Decommissioning (e.g., turbines, foundations, cables)	• Dismantling of port infrastructure and superstructure (e.g., piers, docks, warehouses, cranes)	• Shipbreaking • Fishing and aquaculture equipment	• Shipbreaking and scrapping	• Shipbreaking
Noise	• Vessel sounds (e.g., engines, propellers, machinery, sonars)	• Pile driving • Dredging • Vessel sounds (e.g., engines, propellers, machinery)	• Seismic surveys • Pile driving	• Pile driving • Acoustic vibrations • Service vessel traffic	• Cargo handling and construction activities	• Bottom trawling • Vessels sounds • Fish finders • Constructing and decommissioning aquaculture facilities • Acoustic deterrent devices for farms	• Metal working (welding, cutting, hammering)	• Vessel sounds (e.g., engines, propellers, machinery, sonars)

Alteration of habitats	• Anchoring • Construction of port infrastructure • Sediment resuspension in shallow water • Disturbance from ship navigation	• Modification of the seabed through suction or drilling • Coastal erosion • Turbidity plumes	• Seafloor disturbance and subsidence • Submarine landslide • Anoxic zones • Rig-to-reef	• Impact on the seafloor during construction • Artificial reef • Electromagnetic field from power cables	• Construction and expansion of ports (land reclamation) • Maintenance dredging • Sediment contamination	• Impact of fishing gear on the seafloor (e.g., bottom trawls, dredges) • Destruction of mangroves and coastal wetlands • Seafloor disturbance below the fish farm	• Seabed contamination • Shipyard infrastructure (e.g., dry docks, shipbuilding piers, anchorages) • Turbidity during launching	• Anchoring • Construction of port infrastructure • Sediment resuspension in shallow water • Grounding and sinking • Disturbance from ship navigation
Removal of biomass		• Loss of benthic species from dredging operations				• Fishing catch (including small-pelagics used for aquafeeds) • Bycatch of non-target species • Collection of wild juveniles as stock		
Non-native species	• Ballast water • Transfer of species onboard ferries	• Ballast water • Transport of equipment	• Pipelines • Mobile infrastructures	• Offshore infrastructure provides new habitats • Transport vessels	• Ballast water	• Ballast water • Disruption of food webs • Escape of non-native and genetically-modified organisms	• Biofouling	• Ballast water • Biofouling
Collisions with fauna	• Ship strikes	• Vessel strikes • Impingement and entrainment	• Vessel strikes	• Vessel strikes • Moving turbine blades	• Vessel strikes	• Vessel strikes		• Ship strikes
KEY REFERENCES	1–4	5	6–8	9–13	14–16	17–20	21	22–24

Supplementary Text 1. Summary of ocean impact reporting by core industry of the ocean economy

The following section summarizes the content analysis of sustainability and annual reports of firms across each industry. It first presents the coding results for each type of ocean impact to highlight their materiality in a given industry, and then describes the types of goals companies have set to address these impacts, along with examples of strategies used to achieve those goals.

1. CONTAINER SHIPPING

Most frequently mentioned impacts (Box S1). All nine firms reviewed referenced their energy utilization and greenhouse gas emissions, in one case stating that "climate action is a strategic imperative for our company" (Maersk, 2020, pg 7). All firms also referenced some type of oceanic pollution, largely in terms of wastewater or solid waste. Additionally, seven firms referenced the end-of-life impacts of vessels, and five referenced noise pollution, e.g. from "propeller cavitation, the biggest source of underwater noise from a ship, …generated as the propeller turns in water" (MSC, 2019, pg. 81), while four mentioned oil spills and gas leaks. In terms of other direct effects on biodiversity, less than half (four) of the firms referred to alteration of habitats, while three referred to collisions with fauna such as marine mammals. However, seven of the nine firms mentioned the introduction of non-native species as a result of discharging ballast water.

Box S1. Examples of ocean impacts cited by container shipping firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from container vessels, Scope 3 emissions, e.g. from operations and the transit of goods after reaching port ("value chain").

Oceanic pollution

- Oil spills and gas leaks: oil spills from container vessels.
- Noise pollution: from ship noise, e.g. propeller cavitation.
- End-of-life impacts: from container vessels.
- Other oceanic pollution: waste (solid waste, wastewater).

Other direct impacts on biodiversity

- Collisions with fauna: ship strikes on marine mammals.
- Alteration of habitats: from ship routes, particularly new routes in the Arctic.
- Introduction of non-native species: ballast water discharged from container vessels, biofouling on ship hulls.

Types of goals set to address ocean impacts (Box S2). Eight of the nine firms set measurable goals for energy utilization and greenhouse gas emissions, three for addressing waste, and one for the end-of-life impacts of vessels. None had measurable goals for any of the other ocean impacts referenced. At least three firms had set some form of net zero goal by 2050 (or in one case 2060) while at least six referenced the IMO as a driver of their goals (e.g. its ambition of a 40% reduction in the carbon intensity of shipping by 2030). Firms described these efforts as necessary to strengthen competitiveness (HMM, 2020), respond to requests from consumers (Hapag-Lloyd, 2020) and customers (e.g. "90 of our top 200 customers have set or are in the process of setting ambitious science-based or zero carbon targets" (Maersk, 2020), pg 18), or in anticipation of regulation such as "taxation or other pricing mechanisms as well as disclosure requirements related to CO2 emissions" (Maersk, 2020, pg 16). Additionally, in terms of the end-of-life impacts of container vessels, one firm stated an ambition to create "opportunities globally" for "responsible ship recycling" (Maersk, 2020, pg 7).

Box S2. Examples of goals set by container shipping firms for addressing ocean impacts

Climate change

- Maersk (2020, pg 42): Emission reduction goals include to achieve: "by 2030 60% relative CO2 reduction from shipping [2008 baseline]", "by 2030 have commercially viable, net zero vessels operating in [the] fleet", and "by 2050 have net zero emissions from our own ocean operations."
- CMA (2020, pg. 72): has goals to cut emissions in half by 2030 from 2008 baseline (measured in "maritime emissions efficiency" g CO2/TEU-km), to have "at least 10% of alternative fuels in our energy mix by 2030" and to be carbon neutral by 2050.
- Cosco (2020): aims to peak carbon dioxide emissions by 2030 and for carbon neutrality by 2060.
- Evergreen (2020): Set emission reduction goals of 40% by 2030 and 70% by 2050, with 2008 as baseline.
- HMM (2020, pg. 8): set goal to be carbon neutral by 2050 with an intermediate goal of "GHG reductions of 50% in all fleets and 70% in container fleet by 2030. "In addition, … setting our core KPI to reduce GHG emissions by 60% by 2025 and 70% by 2030 compared to 2008, and to achieve 80% of all ships as ecofriendly ships."
- Hapag-Lloyd (2020, pg. 41): states support for the IMO goals to reduce specific emissions by 40% by 2030 (compared to 2008 baseline), and a reduction of absolute emissions in the industry by 50% by 2050: "we support the IMO's goal of reducing all greenhouse gas emissions from the international shipping industry by 50% by 2050 (base year 2008)."
- MSC (2019): to meet IMO 2030 target for emissions.
- ONE (2020): set medium-term goal of 25% reduction in CO2 emissions by 2030, from 2018 baseline, and longer-term goal of 50% reduction by 2050, from 2018.
- Yang Ming (2020): plans to reduce emissions by 60% by 2025, from 2008 baseline.

Strategies described to address ocean impacts. Most of the greenhouse gas emissions reported by container shipping firms were Scope 1 from operations of the fleet and their fuel use, e.g. from two-thirds (Maersk, 2020) to three-quarters (CMA, 2020), with almost all of the remainder from Scope 3 emissions created along the supply chain. To address these emissions, several firms referred to short-term strategies to increase the efficiency of container vessels and operations (CMA, 2020; Evergreen, 2020; Hapag-Lloyd, 2020; HMM, 2020; Maersk, 2020; MSC, 2019; ONE, 2020; Yang Ming, 2020), including efforts to optimize shipping routes and speeds to reduce fuel consumption (Evergreen, 2020; HMM, 2020; ONE, 2020), "cargo optimization" and developing "real-time" greenhouse gas emissions monitoring systems and an inventory for operations (HMM, 2020), and development of more efficient container vessels, such as "eco-friendly and high-efficiency megaships" (HMM, 2020, pg. 2) or "a new generation of green ships" (Evergreen, 2020, pg. 86), or retrofitting vessels with "propeller boss cap fins" and working to reduce drag on vessels (MSC, 2019, pg. 65). Beyond efficiency measures, some firms focused on switching to container vessels fueled by LNG (Hapag-Lloyd, 2020; Yang Ming, 2020), with one describing retrofits of vessels to use LNG as a 'differentiation strategy' (Hapag-Lloyd, 2020), while others described fleet upgrades that have bow design to reduce hull resistance and engineering to minimize wind resistance (MSC, 2019; ONE, 2020).

In terms of fuel consumption of container vessels, multiple firms described the use of LNG as a 'transition fuel' (CMA, 2020; HMM, 2020; Maersk, 2020), though in one instance a firm stated an ambition to "leapfrog directly to net zero fuels" (Maersk, 2020, pg 6). The firm wrote that "the main limitation to developing net zero emission vessels was the availability of new fuels at scale" (Maersk, 2020, pg 19). Several firms reported strategies focused on developing such alternative fuels, e.g. biodiesel, methanol, lignin fuels and ammonia (Maersk, 2020), or "green hydrogen and other synthetic fuels" (CMA, 2020, pg. 75), 'biofuel blends' and hydrogen (MSC, 2019).

Beyond addressing emissions from container vessels, multiple firms reported strategies that include increasing the efficiency of terminals (Cosco, 2020; Evergreen, 2020; MSC, 2019; ONE, 2020), e.g. ‘clean ports;’ (HMM, 2020) and ‘smart terminals’ (Cosco, 2020), for example through “establishing shore power systems” to supply electricity to vessels when they are at berth, “retrofitting environmentally-friendly lights for energy savings”, “electrification of [port] infrastructure” and “continuous optimisation of yard systems” (Cosco, 2020, pg. 9). Additionally, one firm referenced efforts to work with customers along supply chains to reduce Scope 3 emissions (e.g. “working with customers, partners and regulators to build the market, fuel supply chains and policy frameworks to support net zero emissions shipping” (Maersk, 2020, pg 17). Finally, one firm stated that it planned still to develop its strategy (“roadmap”) to meet the goal of net zero by 2050 (CMA, 2020).

In terms of oceanic pollution from solid waste and wastewater, some companies referenced strategies to prohibit the ‘dumping’ of any waste at sea and store it on vessels to be discarded at ports (Hapag-Lloyd, 2020; Maersk, 2020), while noting that finding adequate port reception facilities can be a challenge (Maersk, 2020). Firms reported a strategy not to discharge any vessel wastewater “within 15/25 nautical miles of the seashore” (Evergreen, 2019, pg. 96), and also focused on solid waste management capabilities at terminals (Cosco, 2020; Evergreen, 2019). Finally, one firm focused on storage and disposal of oil “sludge” (“unusable oil residue that is left when marine oil is processed by the fuel oil purifier” (Evergreen, 2019, pg. 98), while others focused on ensuring the use of ‘non-toxic’ anti-fouling paint on vessel hulls (HMM, 2020; MSC, 2019), to comply with the International Convention on the Control of Harmful Anti-Fouling Systems on Ships that “prohibits the use of harmful …anti-fouling systems” (MSC, 2019, pg. 84).

In terms of pollution from the end-of-life impacts of container vessels, several firms described strategies to use sites for dismantling ships, or requesting that buyers of their vessels use sites that voluntarily[1] comply with the Hong Kong Convention (CMA, 2020; Evergreen, 2020; HMM, 2020; Maersk, 2020), and in one case reported auditing these sites periodically, as well as using third-party monitoring of the sites (CMA, 2020). Multiple firms also described efforts to comply with European Union ship recycling regulations, including maintaining an inventory of hazardous materials on the vessel when coming to European ports (Evergreen, 2020; HMM, 2020; Hapag-Lloyd, 2020; Maersk, 2020; MSC, 2019). Additionally, one firm described direct investment in the shipyards used for recycling container vessels in Alang, India, so that they would voluntarily comply with the Hong Kong Convention, and referenced the firm’s internal “ship recycling standard” (Maersk, 2020, pg. 9). Finally, several firms described their role in the Ship Recycling Transparency Initiative, “which calls for environmentally friendly ship recycling under safe working conditions” (Hapag-Lloyd, 2020, pg. 50) and “includes about 42% of the global container fleet by TEU capacity” (Maersk, 2020, pg. 33), e.g. as “a founding member” (Hapag-Lloyd, 2020, pg. 34), a steering group member (Maersk, 2020), or a firm that “expected to participate” (Evergreen, 2020, pg. 25).

To address noise pollution, one firm referenced the IMO guidelines on noise, including the design or retrofit of propellers to reduce noise (e.g. ‘propeller boss cap fins’) (MSC, 2019), while another referred to “energy efficiency retrofits of vessels” that reduce ship noise, as well as sailing at “slower speeds in areas where [orca] whales have been identified” (Maersk, 2020, pg. 39). In terms of oil spills and gas leaks, multiple firms reported on oil spills of various sizes (CMA, 2020; HMM, 2020; Maersk, 2020; One, 2020), vessel inspections (CMA, 2020; One, 2020), maintenance and drills to prevent spills (CMA,

[1] Since it has not yet entered into force.

2020), as well as in one case equipping vessels with a "Fast Oil Recovery System…..to quickly recover bunker oil through a system of standardized connecters in case of grounding or collision" (CMA, 2020, pg. 82).

Most of the strategies described to address other direct impacts on marine biodiversity focused on the introduction of non-native species, including investments in ballast water treatment systems on vessels (CMA, 2020; Evergreen, 2020; Hapag-Lloyd, 2020; HMM, 2020; Maersk, 2020; Yang Ming, 2020), often noted to comply with the IMO Ballast Water Management Convention[2] (Hapag-Lloyd, 2020; HMM, 2020; Maersk, 2020), and in one instance as a firm's contribution to SDG 14 (Evergreen, 2020). Additionally, strategies focused on investment and use of anti-fouling paint on vessel hulls to prevent aquatic organisms (e.g. barnacles, seaweed, etc.) from attaching to ships and transporting to new ecosystems (HMM, 2020; MSC, 2019), in compliance with the International Convention on the Control of Harmful Anti-fouling Systems in Ships to prohibit the use of 'harmful anti-fouling paints'(MSC, 2019, pg. 84), as well as one firm stating that it had begun to use "underwater robots" for hull cleaning (HMM, 2020). Additionally, one firm reported that its vessels carry a "biofouling management plan" that factors "into account the vessel's trading area, expected environmental conditions and operational requirements related to the prevention of biofouling (e.g. average sea water temperature, fouling severity, speed, dry-docking interval) for, in particular, the propeller, rudder, bow thrusters and sea chests." (MSC, 2019, pgs. 64-65). Finally, one firm noted participation in a "GloFouling project" of the IMO, UNDP and GEF to "reduce the spread of invasive aquatic species" (Hapag-Lloyd, 2020, pg. 49).

Additionally, some firms described strategies to address ship strikes on fauna, including "speed reduction in marine mammal breeding areas….to reduce the risk of collision" (CMA, 2020, pg. 84), "ship speed reduction programs…to reduce the risk of ship strikes for whales" (Evergreen, 2019, pg. 103) and a "traffic separation scheme off Sri Lanka's southern coast in order to protect blue whales on their migration routes" (Hapag-Lloyd, 2020, pg. 50). To address direct alteration of habitats, multiple firms focused on a commitment to avoid using the Northern Sea Route (CMA, 2020; Hapag-Lloyd, 2020; MSC, 2019), "the Arctic sea route that [has] opened up to traffic recently due to the melting of polar ice" (CMA, 2020, pg. 84), e.g. as signatories to the 'Declaration of Refusal to Sail the Arctic Circle' facilitated by Nike and the Ocean Conservancy (Evergreen, 2019; Hapag-Lloyd, 2020). Additionally, one firm mentioned initiating "a program in 2021 to help coral regeneration and support the Great Barrier Reef" (CMA, 2020, pg. 31). More broadly, one firm stated that it was "actively involved in a number of projects aimed at protecting marine ecosystems" (MSC, 2019, pg. 84).

***

[2] The Convention "requires the implementation of a specific ballast water management plan" (Hapag-Lloyd, 2020, pg. 48) and installation of ballast water treatment systems, a "device that disinfects and purifies ballast water before discharging" (HMM, 2020, pg. 58).

2. CRUISE TOURISM

Most frequently mentioned impacts (Box S3). All nine firms reviewed referenced their energy utilization and greenhouse gas emissions, and they also all referenced some type of oceanic pollution, typically wastewater or plastic waste. Three of the firms referenced the end-of-life impacts of vessels (e.g. “ship breaking”), while two each referenced oil spills and noise pollution. In terms of other direct effects on biodiversity, six firms referenced the introduction of non-native species through the discharge of ballast water, six referenced the alteration of habitats broadly (for example in terms of operations in areas of high biodiversity, or impacts of onshore excursions by customers), and one referenced collision with fauna in terms of ‘marine life avoidance’ by vessels.

Box S3. Examples of ocean impacts cited by cruise tourism firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from “ship operations” of cruiselines, also some firms reporting Scope 3.

Oceanic pollution

- Noise pollution: from ‘ship operations’ of cruiselines, e.g. propellers.
- End-of-life impacts: from cruise ships about to be “retired” and/or recycled.
- Oil spills or gas leaks: oil spills from ‘ship operations’ of cruiselines.
- Other oceanic pollution: wastewater from cruiseline ships, and plastic waste on cruiselines, notably single-use plastics.

Other direct impacts on biodiversity

- Alteration of habitats and collisions with fauna: from location ‘ship operations’ of cruiselines, notably near areas of high marine biodiversity, as well as interactions between fauna and ‘ship operations’ of cruiselines, and interactions between species and onshore excursions of customers (e.g. sea turtles).
- Introduction of non-native species: from the discharge of ballast water.

Types of goals set to address ocean impacts (Box S4). In terms of energy utilization, all nine companies reported on their greenhouse gas emissions, with substantial differences in their level of ambition (Box S2). Some firms mentioned ambitions to “achieve net carbon neutral ship operations” (Carnival, 2020, pg. 60) or to “operate completely emission-free” (Hurtigruten, 2018, pg. 2), several referenced the IMO targets as a goal, while others such as Disney Cruiselines (2020) stated that emission reduction goals have been set for the firm’s onshore and offshore operations combined, not just cruise tourism.

For oceanic pollution, no goals were stated for recycling ships at the end of their life, though some firms referenced the aim to comply with European regulations and the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (Royal Caribbean, 2020). Similarly, no goals were articulated for noise pollution or oil spills and gas leaks, rather most goals articulated in addition to greenhouse gas emission reduction focused on oceanic pollution from wastewater and plastic waste. For the former, goals were articulated in terms of installing advanced wastewater treatment systems on ‘ship operations’ of cruiselines (Carnival, 2020; Disney, 2020; Norwegian, 2020; Royal Caribbean, 2020; MSC, 2019), or preventing discharge of wastewater from ships into the sea (Viking, 2020). Firms stated a variety of goals for reducing plastic waste generated in these operations, such as the elimination of plastic straws (Disney, 2020; Viking, 2020), plastic bottles (Norwegian, 2020), and other single-use plastics (Disney, 2020; Royal Caribbean, 2020; Hurtigruten, 2018; MSC, 2019), with TUI (2020) noting that the firm’s goal was based on the International Tourism Plastic Pledge to reduce plastic waste, and Norwegian (2020) reporting membership in the Trash Free Seas Alliance formed by the Ocean Conservancy. In one instance, a firm specifically mentioned the goal of addressing pollution from microplastics (Hurtigruten, 2018). Relatively few goals were articulated by cruise tourism firms in terms of other direct impacts on biodiversity, with exceptions for tracking ‘ship operations’ in marine protected areas (Norwegian, 2020) or supporting the establishment of a marine protected area (MSC, 2019).

Box S4. Examples of goals set by cruise tourism firms for addressing ocean impacts

Climate change

- Carnival (2020. pg. 9, pg. 60): “climate action is our top sustainability focus area”, and aims to “achieve 40% carbon intensity reduction relative to our 2008 baseline”…and “aspire to achieve net carbon neutral ship operations” by 2050.
- Disney Cruiselines (2020, pg. 25): targets and strategy set for whole company, not just cruiselines; had 2020 target to reduce net GHG emissions by 50% from 2012 levels, and commits to “net zero emissions for direct operations by 2030”, and “100% zero carbon electricity by 2030.”
- Genting Hong Kong (2020): target to reduce GHG emissions by 10% by 2025 from 2019 baseline.
- MSC (2019, pg. 14, pg. 18): Notes that “the cruise industry is committed to a 40% reduction in carbon emissions intensity by 2030, compared to 2008” and “We support the IMO’s level of ambition for a 40% reduction in carbon emissions intensity by 2030, and a 70% reduction by 2050, both compared to the 2008 baseline, as well as a 50% reduction in total greenhouse gas emissions compared to 2008 levels by 2050, aiming to eliminate them as quickly as possible in this century.”
- Norwegian (2020, pg. 4): target of “40% reducing in industry-wide carbon emissions rate by 2030.”
- Royal Caribbean (2020): target to reduce emissions 35% below 2005 levels, by 2020, and in 2020 set new target to reduce emissions intensity an additional 25% from 2019 levels by 2025.
- TUI Cruises (2019): targeting reduction in fuel consumption per person per night – 2% compared to 2019; also reduction of CO_2 emissions per person per night by 1% from 2019.

Oceanic pollution

- Other types of oceanic pollution:
  - Wastewater:
    - Carnival (2020, pg. 10): set targets to “increase fleetwide coverage of Advanced Waste Water Treatment Systems to >75% by 2030.”
  - Plastic waste:
    - Viking (2020, pg. 24): “Our goal is to prevent plastic from entering the sea from our vessels and thus to reduce the environmental impact of plastic. We have therefore replaced classic plastic straws on board with straws made from biodegradable material.”

Strategies described to address ocean impacts (Box S5). The types of greenhouse gas emission reduction strategies described in the reports most frequently focused on the use of “alternative fuels” for vessels, e.g. using or switching to liquified natural gas (LNG) as a fuel (Disney, 2020; Hong Kong, 2020; Hurtigruten, 2018; MSC, 2019; Royal Caribbean, 2020), fuel cells or liquified synthetic methane (Carnival, 2020), or in one case refitting some vessels to include “propulsion on batteries and from biogas created from rotten fish and other organic waste” (Hurtigruten, 2018, pg.2). In terms of fuel choice, Hurtigruten (2018, pg.12) stated that the firm was “advocating a global ban on heavy fuel oil”, which “has been banned on all our ships for over a decade”. Several firms also focused on increasing the efficiency of vessels (Carnival, 2020; MSC, 2019; Royal Caribbean, 2020) and ‘shore power connection capability’ (Carnival, 2020, MSC, 2019). Finally, in some instances, firms included offsets as part of their strategies, e.g. MSC (2019, pg. 21) stated that “in the future, we are committed to supporting blue carbon projects which protect and restore ocean habitats, support local communities, and absorb more carbon than other means (…) Blue carbon offsets are currently scarce, so we are working to support and develop the methodology for assessing ocean-based carbon sequestration and subsequently source approved ocean-based carbon offsets." Similarly, Norwegian (2020, pg. 25) committed to "purchase verified carbon credits to offset three million metric tons of carbon dioxide equivalent, over a three-year period beginning 2021."

For oceanic pollution, multiple firms reported installing 'advanced wastewater treatment systems' to treat onboard wastewater on more or all vessels (Carnival, 2020; Disney, 2020; MSC, 2019; Norwegian, 2020), and one stated that their "vessels do not discharge any wastewater into the sea" (Viking, 2020, pg. 4). In terms of plastic waste, several firms reported banning the use of specific single-use plastic items from their operations (Disney, 2020; Hurtigruten, 2018; MSC 2019; Norwegian, 2020; Royal Caribbean, 2020), transitioning to "recyclable, reusable or biodegradable" items (MSC, 2019, pg. 69), or substituting plastic products with non-plastic alternatives (Disney, 2020; Hurtigruten, 2018) – in some cases measuring reductions in total plastic waste volumes (Disney, 2020). Finally, one firm described a strategy to address microplastics by reducing the use of polymer-based clothing (Hurtigruten, 2018). For pollution resulting from end-of-life for cruise vessels, at least two firms described strategies based on the EU Ship Recycling Regulation (Carnival, 2020; Royal Caribbean, 2020), and in one case the Hong Kong Treaty on ship recycling (Royal Caribbean, 2020). For noise pollution, one firm described a strategy of designing, building and installing hulls and propellers on cruise vessels to minimize "noise or vibration that might impact aquatic animals" (MSC, 2019, pg. 12), while another reported carrying out underwater sound surveys for three vessels and qualifying for and receiving "SILENT-E class notation, which applies to vessels demonstrating a controlled environmental noise emission and ensures that vessels do not exceed typical average-to-moderate underwater noise levels" (Norwegian, 2020, pg. 45). For oil spills, one firm described the use of technology that uses laser equipment to periodically identify and classify hydrocarbons present in the water by fuel type, to identify incidents of oil spillage (Hurtigruten, 2018).

Box S5. Example of a strategy to recycle cruise ships

Carnival (2020, pg. 31) reported the results of working with a non-profit participating in the NGO Shipbreaking Platform and ship recycling experts Sea2Cradle, to develop an approach for recycling ships, based on formulating a "Ship Recycle Plan" for each vessel, to ensure compliance with relevant standards. "Each plan will include a complete inventory of hazardous and regulated materials and the procedures planned for safely removing and processing the materials in an environmentally friendly way. Once these materials are safely removed and processed, the companies will begin dismantling each ship. Ships will be stripped of machinery, electronic equipment, glass, wood, and other materials that can be directly up-cycled for reuse in new ships, used in ship repair or repurposed for other applications. Steel and metal scraps will be salvaged and recycled for direct use or be sent to the mill for producing other products (…)".

In terms of other direct impacts on biodiversity, some firms described strategies to support marine protected areas or priority areas for conservation at cruise destinations (Royal Caribbean, 2020), e.g. aiming to support the Government of Bahamas to turn a marine protected area into a National Marine Park (MSC, 2019), or an ambition to track future cruise duration in marine protected areas and areas of conservation status (Norwegian, 2020). To address collisions with fauna, one firm described compliance with seasonal shipping lane changes, ship speed reductions and voluntary reporting, as well as conducting 'marine life avoidance' training for captains and first officers before each season in Alaska (Disney, 2020). To address the introduction of non-native species, firms reported efforts to increase the number of vessels equipped with ballast water treatment systems (Carnival, 2020; Norwegian, 2020; MSC, 2019), as well as coating hulls of ships with "specific paints to slow the growth of barnacles, algae and other marine organisms" (MSC, 2019, pg. 22).

***

3. MARINE EQUIPMENT AND CONSTRUCTION

Most frequently mentioned impacts (Box S6). All ten firms reviewed referenced their energy utilization and greenhouse gas emissions, with one firm stating that "by its very nature, marine contracting tends to be energy intensive" (DEME, 2020, pg. 38). Nine of the firms also referenced some type of oceanic pollution, typically wastewater or solid waste, though in some cases specifying plastic waste. Additionally, in terms of pollution, eight firms referenced oil spills or gas leaks, while seven referenced end-of-life impacts and six referenced noise pollution. Of these, one firm stated that "preventing and reducing marine pollution of all kinds through our marine salvage business" was a "cornerstone" and "core of our business" (Royal Boskalis, 2020, pg. 17), while another mentioned that "environmental risks that have the severest impact on the [firm] are accidental oil spills, coating operations and noise issues (Hitachi Zosen, 2020, pg. 51)." Another wrote that noise pollution was "an increasingly important issue in the shipping industry" (Wartsila, 2020, pg. 37).

In terms of other direct effects on biodiversity, six firms referenced the alteration of habitats and four referenced the introduction of non-native species, with one stating that "avoiding the introduction of alien invasive species" was one of the most "significant biodiversity pressures related to our business" (Royal Boskalis, 2020, pg. 63). In several instances, firms referenced the importance of these direct impacts on marine biodiversity broadly, e.g. as a "sustainability focus area" (Royal Boskalis, 2020, pg. 15), or stating that "it is undeniable that marine contracting (e.g. dredging, harbour extensions, offshore wind turbine installation, underwater cable laying) alters the environment" and that it was "important to find sustainable solutions that safeguard and improve marine and terrestrial ecosystems by de-polluting, restoring and enhancing our rivers, coastal areas, ports and land (DEME, 2020, pg. 48)."

Box S6. Examples of ocean impacts cited by maritime equipment and construction firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from marine contracting activities, e.g. from fuel consumed by vessels.

Oceanic pollution

- Oil spills and gas leaks: oil spills from salvage operations and vessels, oil fuel spills from equipment.
- Noise pollution: noise from installation of subsea infrastructure.
- End-of-life impacts: vessels, e.g. dredging vessels, maritime equipment.
- Other oceanic pollution: waste (solid waste, wastewater), in some cases specifying plastic waste.

Other direct impacts on biodiversity

- Alteration of habitats: turbidity ("sediment plume"), disturbances to seabed habitats from land reclamation or installation of offshore structures, installation of new subsea infrastructure ("trenching and rock dumping…to install flow lines").
- Introduction of non-native species: from discharge of ballast water, or organisms attached to vessel hulls.
- Collisions with fauna: "animal strikes" from vessels.

Types of goals set to address ocean impacts (Box S7). While all firms reported on their greenhouse gas emissions, only eight articulated measurable goals for emission reductions, most frequently focusing on reducing Scopes 1 and 2 emissions to varying levels, though in some cases not disaggregated between the firm's maritime and terrestrial activities. The level of ambition varied between firms, with several aiming for net zero by 2050 (DEME, 2020; Royal Boskalis, 2020; Van Oord 2020), including in at least one case Scope 3 emissions (Van Oord, 2020). Two firms set measurable goals (targets) for addressing oil spills and gas leaks. For other types of oceanic pollution, typically wastewater or solid waste, some firms reported maritime and terrestrial impacts together, and only three set measurable goals. No firms set measurable goals for noise pollution or end-of-life impacts.

In terms of other direct impacts on marine biodiversity, no firms set measurable goals, though one mentioned the desire to have "a net positive impact on biodiversity and ecosystems" (DEME, 2020, pg. 25). Two firms articulated an ambition to be leaders in habitat restoration (as "unique in the sector"), based on construction projects and capabilities, e.g. "Van Oord is well-positioned to contract large-scale ocean health restoration projects in places where reefs, seagrass fields, mangroves or corals have been damaged in the past" (Van Oord, 2020, pg. 47); or the ambition "to lead the industry in the development of nature-based solutions to protect and enhance coastal ecosystems" through "expand[ing] the knowledge base and commercial reach of our nature-based solutions" and "further develop[ing] our methodology to measure and manage our biodiversity impact through the application and evolution of our biodiversity framework" (Royal Boskalis, 2020, pg. 17).

Box S7. Examples of goals set by maritime equipment and construction firms for addressing ocean impacts

Climate change

- Aker (2020): "to reduce absolute emissions (scope 1 and scope 2) by 50 percent by 2030, using 2019 as a baseline."
- DEME (2020, pg. 24): Company's goal is to be "climate-neutral" by 2050 (with intermediate goal to reduce emissions by 40% by 2030, relative to 2008), and to expand marine renewable energy production through "transport, installation and maintenance of offshore wind farms", and by "exploring new marine-based solutions for renewable energy production, connection and storage."
- Hitachi (2020): targets for emission reductions of 3.8% by FY2020, compared to FY2005.
- Royal Boskalis (2020): set a goal to have net zero scopes 1 and 2 emissions by 2050.
- Subsea (2020, pg. 13): aiming to "achieve a 50% reduction by 2050."
- Technip (2020): set a goal to reduce scopes 1 and 2 emissions 50% by 2030 (compared to 2017); also committed to establish scope 3 reduction targets by 2023.
- Van Oord (2020, pg. 44): set a goal "to become carbon neutral by 2050" across scopes 1, 2 and 3 "in line with the EU Green Deal", with intermediate goals of 2.5% reduction per year.
- Wartsila (2020, pg. 20): has goals to "contribute to the development of an affordable, reliable, sustainable and modern power system worldwide"; to "become a global actor in the LNG value chain"; "to contribute to the development of more sustainable transportation through gas technology, fuel flexibility, energy efficient technology, and voyage optimization"; "to reduce CO2 emissions from vessels by more than 300,000 tons annually."

Oceanic pollution

- Oil spills and gas leaks:
    - Aker (2020): set a target for 2021 of zero spills.
    - Royal Boskalis (2020, pg. 17): sets a goal "to prevent any oil (products), pollutants and/or hazardous cargo from salvaged vessels entering the marine and coastal environment",…"zero spill ambition".
    - Technip (2018, pg. 50): "aims to achieve zero spills or releases" and to avoid "harm[ing] marine ecosystems".
- Other types of oceanic pollution:
    - DEME (2020b, pg. 24): states goal to "accelerate the shift towards a circular economy", including addressing plastic pollution, "environmental dredging and sediment treatment", and "treatment of process water".
    - Subsea7 (2020): goal for zero single use plastics.
    - Subsea7 (2020, pg. 15): "We have set targets of recycling 90% of all onshore waste by 2025, and of

Strategies described to address ocean impacts (Box S8). Multiple firms mentioned plans for emissions reductions, including in one instance a "CO2 Emissions Reduction Program" focused on five areas: "fuel efficiency", "new energy sources", "carbon offset and credits", "trends, regulations and collaboration – working with others and keeping a close eye on emerging regulations and future trends in low carbon shipping", and "commercial offering – raising awareness of our solutions and making it simpler for clients to select lower-carbon options for their projects (Royal Boskalis, 2020, pg. 58)." Most frequently, firms focused on increasing the fuel efficiency of fleets, e.g. through alternative fuels such as dredging vessels that use LNG fuel (DEME, 2020; Royal Boskalis, 2020; Subsea7, 2020; Technip, 2020; Van Oord, 2020; Wartsila, 2020), "LNG hoppers, water injection hoppers, electric excavators" (Van Oord, 2020, pg. 61), and increasing purchase of renewable electricity at work sites (DEME, 2020). Additional strategies included working to "establish an internal carbon price for the entire company" (Technip, 2020, pg. 62), "providing the carbon footprint of all our deliverables to clients" (Technip, 2020, pg. 49), and "engaging with clients to reduce the environmental impact of our services", e.g. through the use of a "carbon calculator tool" to consider the emissions linked to different project alternatives (Subsea7, pg. 12). Finally, several firms mentioned shifting their business strategy to become leaders in "energy transition", e.g. through supporting offshore wind (for example building floating platforms) or decommissioning offshore oil and gas facilities (Saipem, 2020; Subsea7; Royal Boskalis, 2020; Van Oord, 2020). For example, one firm stated that it expected a "different future for dredging" given the energy transition, and that "as the balance shifts away from fossil fuels, we will apply our business unit's capabilities – marine construction in an offshore environment – to new areas", including carbon capture and storage (Van Oord, 2020, pg. 26). Similarly, another firm anticipated that the expansion of offshore wind would occur in the short-term, but other marine renewables would become part of the longer-term transition (e.g. floating solar, wave and current energy, etc.) (Saipem, 2020).

Box S8. Example of a maritime equipment and construction firm considering blue carbon offsets as part of its strategy to reduce emissions

"As part of our actions to develop a low-carbon future for Boskalis we actively investigate sustainable options for offsetting residual emissions and preparing for potential future carbon markets. Early 2020, we signed a new collaboration agreement with Wetlands International, the global NGO dedicated to safeguarding and restoring wetlands, to carry out studies into the feasibility of developing 'blue carbon' opportunities. Blue carbon refers to the (organic) carbon stored in marine and coastal ecosystems, mostly mangroves, salt marshes and seagrasses. This type of coastal vegetation reduces the energy flow of the water and dampens waves and currents. As a result, any floating biomass or suspended sediment, with its associated carbon, is deposited onto the seabed where it is trapped under further layers of sediment, creating carbon storage, known as a 'carbon sink'. The biomass of the vegetation itself (leaves, branches, stems) is added to the mix. If these ecosystems are disturbed however, this stored carbon is rapidly released into the atmosphere. Our first focus in this project has been to combine our own expertise and knowledge with that of Wetlands International to identify locations with significant blue carbon wetlands, explore climate change policies and start business case development. Next steps will be to join forces with specialists in carbon project development and finance. We will explore ways of conserving, restoring and constructing these 'blue carbon wetlands' with the potential to generate carbon credit, to offset Boskalis' residual emissions and to explore the creation of carbon-balancing options for clients. Safeguarding, restoring and creating mangroves and other blue-carbon ecosystems has the added benefit of enhancing biodiversity both above and below the water. Mangroves are typical nurseries for fish and crustaceans, a plus for local fishing activities, and they are home to a rich diversity of birds and reptiles. Mangrove zones hold the potential for a nature-based solution to help counter the threat of rising sea-levels, storms and floods associated with climate change. Mangroves can also sustain employment, livelihoods and human wellbeing and as such are important for local communities. In our blue carbon collaboration we strive to maximize these climate, community and biodiversity benefits."

Source: Royal Boskalis (2020, pg. 59)

To address oil spills and gas leaks, firms focused on ensuring all sites/projects had “specific accidental pollution contingency plans”, increasing the number of “spill drills” (Saipem, 2020, pg. 58), and measuring and reporting on impacts (e.g. the number or volume of spills) (Subsea7, 2020). Another firm described a strategy focused on reducing oil leakage with water lubricated seals, as well as training and awareness-raising, and inspection of equipment (Technip, 2018). For example, “once the environmental risk is identified, specific measures can be put in place such as containment bounding or barriers, additional spill or pollution response kits, drainage oil interceptors, as well as training, awareness and procedural measures, including by subcontractors” (Technip, 2018, pg. 52). Finally, at least one firm noted that their salvage operations reduced pollution from spills, highlighting their work with “ship owners, insurance companies, terminal operators and classification societies to help prevent incidents” (Royal Boskalis, 2020, pg. 35).

To address noise pollution, several firms described the development of mitigation technologies such as a ‘bubble curtain’ (Van Oord, 2020b), “solutions for propellers”, “double suspension for engines”, and the “development of customized silent modes for vessel operations” (Wartsila, 2020, pg. 37). One case study mentioned developing “the world’s largest vibratory hammer” to reduce the noise levels during monopile foundation installation, by “driv[ing] monopiles to full depth by means of vibro-driving only” (Subsea7, 2020, pg. 7). For end-of-life impacts, most firms reported relatively little in terms of marine equipment, focusing rather on decommissioning services provided to other industries (e.g. decommissioning and removing offshore oil platforms). Exceptions included the descriptions of the recycling of vessels according to the Hong Kong Convention and the EU’s Ship Recycling Regulation (Subsea7, 2020). In terms of other types of oceanic pollution, multiple firms focused on reducing or eliminating single-use plastics in their operations (Saipem, 2020; Subsea7; Technip, 2020). In one example, a firm referenced signing the “UK Chamber of Shipping charter which seeks to eliminate non-essential single-use plastic” and developing “a plastic estimator tool…to review our global single-use plastics” (Subsea7, 2020; pg. 15, Van Oord, 2020).

For other direct impacts on marine biodiversity, firms described innovations to minimize impact, such as techniques to “eliminate the need for trenching and rock dumping” in the installation of undersea cables or pipelines (Subsea 7, 2020, pg. 14), or technologies to monitor dredging plumes to limit the spread of turbidity and impacts on corals and seagrass (Van Oord, 2020). At least two firms described a focus on habitat restoration associated with construction (Royal Boskalis, 2020; Van Oord, 2020) (Box S9), including a goal to “lead the industry in the development of nature-based solutions to protect and enhance coastal ecosystems” (Royal Boskalis, 2020, pg. 17), and describing the firm as “well-positioned to contract large-scale ocean health restoration projects in places where reefs, seagrass fields, mangroves or corals have been damaged in the past” (Van Oord, 2020, pg 47). Examples included an experimental oyster reef at an offshore wind farm site where the firm installed the monopiles for the turbines, as well as the installation of coral nurseries and artificial reef construction (Van Oord, 2020).

Finally, in terms of strategies to address the introduction of non-native species from the discharge of ballast water, similar to companies in other industries with large vessels, firms described compliance with the IMO’s Ballast Water Management Convention (Royal Boskalis, 2020), installation of ballast water management systems (Wartsila, 2020), as well as “vessel cleaning and decontamination” (Subsea7, 2020, pg. 14).

Box S9. Example of efforts to develop a "biodiversity framework" for a maritime equipment and construction firm

"Based on our existing approaches, the recommendations made by IUCN and our findings in the business, we have drafted a biodiversity framework that identifies biodiversity priorities and clarifies our ambition and objectives for biodiversity. These cover the protection of marine and coastal habitats, spill mitigation, the introduction of alien invasive species, habitat restoration, turbidity and animal strikes. …Looking forward, Boskalis will evaluate and further improve the framework by, for example, testing potential data indicators in project sites around the world. Many of the potential indicators are already partially or wholly being reported at the project and/or fleet level (e.g. spills, animal strikes, turbidity and ballast water practices). Others require a deeper level of thought (e.g. habitat protection and enhancement, and nature-based solutions)."

Source: Royal Boskalis (2020, pg. 63)

***

4. OFFSHORE OIL AND GAS

Most frequently mentioned impacts (Box S10). All nine firms reviewed referenced greenhouse gas emissions from energy utilization, as well as oil spills and gas leaks, and other forms of oceanic pollution - most frequently solid waste and wastewater, but also plastic pollution, in case the production of petrochemicals used to make plastic and subsequently pollution (Shell, 2020). Additionally, five of the nine firms referenced the end-of-life impacts of materials used, and two cited noise pollution from offshore activities. Eight of the nine firms mentioned alteration of habitats, and two cited collisions with fauna and the introduction of non-native species. One firm described "biodiversity, oceans & sensitive areas" as a "material topic" (Equinor, 2020, pg. 5).

Box S10. Examples of ocean impacts cited by offshore oil and gas firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from offshore oil and gas production, Scope 3 emissions from consumption of oil and gas produced.

Oceanic pollution

- Oil spills and gas leaks: oil spills and gas leaks from offshore wells and production facilities.
- End-of-life impacts: from offshore oil and gas platforms and wells.
- Other oceanic pollution: waste (solid waste, wastewater), oil cuttings, plastic pellets from operations.

Other direct impacts on biodiversity

- Alteration of habitats: from the location of offshore oil and gas exploration and production sites, with a focus on marine protected areas, World Heritage Sites, etc.
- Collisions with fauna: from offshore oil and gas exploration and production activities, with a focus on marine mammals near offshore sites, as well as endangered or vulnerable species.
- Introduction of non-native species: from vessels supporting offshore oil and gas exploration and production sites, in discharged ballast water.

Types of goals set to address ocean impacts (Box S11). Measurable goals set by the firms were largely focused on greenhouse gas emissions, with all companies setting goals, and to a lesser extent other forms of oceanic pollution such as waste and plastic pollution (five firms) and oil spills and gas leaks (two firms). For other direct impacts on marine biodiversity, three firms set measurable goals to address the alteration of habitats. At least two firms stated a broad ambition "to have a positive impact on biodiversity" (Shell, 2020, pg. 88) or "enhance biodiversity" (BP, 2020, pg. 27)[3], while another reported that a "corporate project has been established to better understand our most material impacts and to develop a new corporate position and an improvement plan for how biodiversity aspects can be better managed in our projects and operations" (Equinor, 2020, pg. 44). Though not specific to oceans, this ambition was articulated in one case as a firm-wide "biodiversity position" with three goals: (i) "to achieve a net positive impact on biodiversity in our new projects", (ii) "to enhance biodiversity around our existing major operating sites", and (iii) "to support biodiversity restoration and the sustainable use of natural resources projects in countries where we operate" (BP, 2020, pg. 27).

[3] Defined "net positive impact" as "when the negative impacts on biodiversity caused by a project are outweighed by measurable outcomes from actions taken in accordance with the mitigation hierarchy to achieve society sustainable biodiversity gain" (BP, 2020, pg. 67).

Box S11. Examples of goals set by offshore oil and gas firms for addressing ocean environmental impacts

Climate change:

- BP (2020, pgs. 24, 34):
  - "net zero operations" - "to be net zero across our entire operations on an absolute basis by 2050 or sooner" (Scope 1 and 2 emissions – aiming for 20% reduction from 2019 baseline by 2025, and 30-35% by 2030);
  - "net zero oil and gas" - "to be net zero on an absolute basis across the carbon in our upstream oil and gas production by 2050 or sooner" (Scope 3 – aiming for 20% reduction from 2019 baseline by 2025, and 30-40% by 2030);
  - "halving intensity" - "to cut the carbon intensity of the products we sell by 50% by 2050 or sooner" (per unit of energy – CO_2e/MJ, with goal to reduce by 5% by 2025 compared to 2019 baseline, and 15% by 2030);
  - "reducing methane" - "to install methane measurement at all our existing major oil and gas processing sites by 2023, publish the data, and then drive a 50% reduction in methane intensity of our operations";
  - "more $ for new energies" - "to increase the proportion of investment we make into our non-oil and gas businesses" and
  - "more clean energy" - "to develop enough clean energy to benefit more than 36 million people". Also states a goal "to reduce our oil and gas production by around 40% by 2030."
- Equinor (2020, pg. 18):
  - "net zero emissions for 1, 2 and 3 by 2050", i.e. "including emissions from the use of the energy we provide", and "100% net carbon intensity reduction by 2050" and to "reduce maritime emissions by 50% in Norway by 2030 and globally by 2050" (compared to 2008 baseline).
  - goal to have "profitable growth in renewables" aiming to "increase renewable energy capacity to 4-6 GW by 2026 and 12-16 GW by 2035" (installed capacity, from a 2019 baseline of "0.5 GW equity capacity").
  - to be "industry leading in carbon efficiency".
- Exxon (2020, pg. 5): states goals of "15-20% reduction in greenhouse gas intensity of our upstream operations", "supported by "40-50% reduction in methane intensity" and "35-45% reduction in flaring intensity", "expected to deliver an absolute reduction of ~30% in greenhouse gas emissions in our upstream business" compared to 2016 baseline.
- Petrobras (2020, pg. 29): set six goals for emissions:
  - "reduction of total operational absolute emissions by 25% by 2030";
  - "zero routine flare burning until 2030";
  - "rejection of approximately 40 MM ton CO_2 by 2025 in carbon capture, use and storage projects";
  - "32% reduction in carbon intensity in the E&P segment by 2025 (15kgCO_2e/boe maintained until 2030)";
  - "40% reduction in the intensity of methane emissions in the E&P segment by 2025"; and
  - "16% reduction in carbon intensity from refining by 2025, increasing to 30% by 2030 (30kgCO_2e/CWT)".
- Qatar (2020, pgs. 15, 45): states that "90%+ gas share by 2030 is our ambition, while achieving net reduction in the carbon intensity of our upstream and LNG operations". "Climate ambition" includes goals for: (i) 0 routine flaring by 2030, (ii) achieve a 0.2 wt.% methane intensity target by 2025, and (iii) aim to reduce scope 1 and 2 emissions from LNG facilities by 25% by 2025.
- Shell (2020, pgs. 7, 8, 32, 88):
  - states a goal to be net zero by 2050. describes long-term goal to "reduce the carbon intensity of the energy products we sell, in step with society", with a short-term goal to "reduce our Net Carbon Footprint by 2-3% by 2021, compared to 2016" and then 3-4% by 2022 and 6-8% by 2023 with longer-term reductions of 20% by 2030, 45% by 2035 and 100% by 2050.
  - also goal to "reduce flaring in our upstream business", expecting to "end routine flaring of gas from the assets we operate" by 2030.
  - a goal "for our Upstream and Integrated Gas facilities, achieve a GHG intensity of 0.162 tonnes or below of CO_2 equivalent per tonne of hydrocarbon production available for sale".
  - a goal "for our refineries, reduce GHG intensity to 1.02 tonnes or below of CO_2 equivalent per Solomon's Utilized Equivalent Distillation Capacity (UEDC)" and "for our chemical plants, reduce GHG intensity to 0.96 tonnes or below of CO_2 equivalent per tonne of high value petrochemicals produced."
- Total (2020, pg. 11):
  - "Net zero across Total's worldwide operations by 2050 or sooner (Scope 1+2).
  - "Net zero across all its production and energy products used by its customers in Europe by 2050 or sooner (Scope 1+2+3)".
  - "60% or more reduction in the average carbon intensity of energy products used worldwide by Total customers by 2050, with intermediate steps of 15% by 2030 and 35% by 2040 (Scope 1+2+3).

Box S11. ***[continued]***

Oil spills and gas leaks

- Shell (2020, pg. 8): states a goal of "no operational spills".

Oceanic pollution

- Petrobras (2020, pg. 29): goal for "zero growth of process waste generation by 2025".
- Exxon (2019, pg. 14): states a goal "to have zero pellet loss to the environment".
- BP (2020, pg. 73): goal "in Europe, all bp-owned food brand packaging to be reusable, recyclable, or bio-degradable by 2025".
- Total (2020, pg. 40):
    - goal to "recycle more than 50% of the waste from Group-operated sites" and of "producing 30% of its polymers from recycled materials by 2030".
    - goal to "maintain the hydrocarbon content of water discharges below 30 mg/l for offshore sites and below 15 mg/l for onshore and coastal sites".

Alteration of habitats

- Petrobras (2020, pg. 29): "100% of Petrobras installations with a biodiversity action plan by 2025".
- BP (2020, pg. 67): sets goals for "100% of major operating sites in sensitive areas implementing enhancement plans" by 2025 and by 2025 at "to support biodiversity restoration and the sustainable use of natural resources" by having 5 "projects in progress or established delivering measurable benefits for biodiversity and people", and 10 by 2030.

The measurable goals set for greenhouse gas emissions reductions from energy utilization varied significantly across the firms (Box S11), with four firms setting goals of net zero for Scopes 1 and 2 emissions, and two setting a net zero goal for Scope 3 emissions (while two others set reduction goals for Scope 3 emissions). Offshore oil and gas emissions were usually aggregated with onshore emissions.

Strategies described to address ocean impacts. Most firms described detailed strategies, albeit with varying levels of ambition, for achieving emissions reduction goals (Box S11). These strategies typically include:

- Accelerating the growth of renewable energy production (BP, 2020; Equinor, 2020; Qatar, 2020; Shell, 2020; Total, 2020), e.g. floating offshore wind as "the next wave of scalable renewables" (Equinor, 2020, pg. 25), as well as bioenergy (BP, 2020);
- Investing in the development of "more efficient" and "low carbon technologies" as products (BP, 2020; Equinor, 2020; Exxon, 2020; Petrobras, 2020; Saudi Aramco, 2019; Shell, 2020; Total, 2020), to "help customers reduce their carbon emissions" (BP, 2020, pg. 37), citing "low-carbon fuels for shipping" and "zero carbon fuels" (Equinor, 2020, pg. 19), biogas (BP, 2020), hydrogen (BP, 2020; Equinor, 2020; Shell, 2020), biofuels (Exxon, 2020; Petrobras, 2020; Shell, 2020), increased production of LNG (as a "destination fuel" rather than a "bridge") (Qatar, 2020, pg. 12), natural gas (Shell, 2020), etc. in some cases specifying that these investments would be funded by "cash flows from our oil, gas and refining activities" (BP, 2020, pg. 30), and considering these investments as providing the firm "with a competitive edge" (Saudi Aramco, 2019, pg. 9);
- Investing in carbon capture and storage (CCS) (BP, 2020; Equinor, 2020; Exxon, 2020; Petrobras, 2020; Qatar, 2020; Saudi Aramco, 2019; Shell, 2020; Total, 2020), including 'nature-based solutions' (BP, 2020; Equinor, 2020; Shell, 2020; Total, 2020), for "sectors that cannot easily be decarbonized, such as industry, maritime transport, heating and flexible power generation" (Equinor, 2020, pg. 26), e.g. investments in nature-based solutions "such as forests

and wetlands that store carbon" on the order of $100 million annually (Shell, 2020, pg. 88; Total, 2020);

- Reducing gas flaring (Petrobras, 2020; Saudi Aramco, 2019; Shell, 2020; Total, 2020; Pemex, 2019), for example through the World Bank's flaring initiative (Shell, 2020; Saudi Aramco, 2019; Qatar, 2020);
- Reducing emissions from existing operations (Scopes 1 and 2 emissions), including 'shipping emissions' (Shell, 2020), "electrifying (…) processes" (Total, 2020, pg. 13) and "reducing methane emissions" (Total, 2020, pg. 3), as well as broad efforts to increase the energy efficiency of operations (Exxon, 2020; Saudi Aramco, 2019; Qatar, 2020; Pemex, 2019); and
- "Proactively engaging in climate-related policy" (Exxon, 2020, pg. 5).

In terms of addressing oil spills and gas leaks, all firms reported on a range of indicators to track oil spills and gas leaks. Multiple firms described strategies based on relatively common elements including: **(i)** procedures for risk management and spill prevention (BP, 2020; Equinor, 2020; Pemex, 2019; Shell, 2020; Total, 2020), including maintenance measures aiming to reduce leaks, methane leak detection and repair programs, and monitoring efforts including drones and other aircraft (Shell, 2020), and standards and criteria for selecting ships and barges for charters to transport oil and gas (Total, 2020); **(ii)** emergency response procedures, capacities and plans (Petrobras, 2020; Pemex, 2019; Shell, 2020, Total, 2020), e.g. "subsea capping" procedures for wells (Total, 2020, pg. 241); and **(iii)** development of new mitigation technologies, e.g. "subsea dispersant injection" so that "fresh oil is treated prior to oil weathering and spreading on the sea surface" (Equinor, 2020, pg. 47).

For other oceanic pollution, multiple firms referenced investments in wastewater treatment (BP, 2020; Petrobras, 2020; Qatar, 2020; Total, 2020), notably in terms of addressing oil in water discharged, as well as treatment via constructed wetlands "where possible" (Shell, 2020, pg. 59) and solid waste management, both hazardous and non-hazardous (Equinor, 2020; Petrobras, 2020; Qatar, 2020; Shell, 2020), including in one instance a "Discarded Wastewater Effluent Volume indicator" and operation of "an oil recovery unit" as part of a strategy "in line with the concept of a circular economy" (Petrobras, 2020, pg. 156). Firms also reported investment in reducing, reusing and recycling materials (Qatar, 2020). Additionally, a firm reported monitoring "drill cuttings", e.g. testing in "thermomechanical cuttings cleaning for oiled drill cuttings", stating that the process "reduces the oil content on the cuttings to meet offshore discharge regulations" (Equinor, 2020, pg. 48), Finally, at least two firms focused on monitoring programs (Qatar, 2020), e.g. launching in 2020 a 3-year plan to "restructure the way waste production across the group will be recorded" (BP, 2020, pg. 74).

In terms of plastic pollution, one firm stated that it was "exploring ways to reduce, reuse and recycle packaging across our supply chain and introduce sustainable packaging solutions" …[including] "large recyclable plastic line bags for bag-in-box lubricant packaging, which reduces plastic use by more than 80% and carbon dioxide (CO2) equivalent emissions by more than 60%, compared with traditional single-use plastic bottles" (Shell, 2020, pg. 62). Additionally, a firm described pyrolysis as part of its strategy to address plastic pollution, for "hard-to-recycle plastic waste into a liquid, which we can then process into chemicals that are used to make new plastics", with an "ambition to use 1 million tonnes of plastic waste a year in our chemical plants globally by 2025" (Shell, 2020, pg. 62). Another included in its efforts "incorporating a criterion dedicated to the circular economy into the company's purchasing" (Total, 2020, pg. 245). Finally, a firm focused on "plastic pellet loss" from operations, reporting that it had "put in place a global standard across all of our resin-handling facilities", including initiatives to monitor for pellet loss and recover any "pellets captured in our water drainage systems" (Exxon, 2019, pg. 14).

For end-of-life impacts, firms focused on the decommissioning of offshore oil and gas facilities, including wells (BP, 2020; Pemex, 2019), citing in one case an effort to "continue to pursue opportunities [to] reuse, repurpose or recycle materials in decommissioning and ways to integrate a circular economy approach into designing future projects" (Shell, 2020, pg. 60).

For other impacts that directly affect marine biodiversity, strategies largely focused on the alteration of habitats, and to a lesser extent collisions with fauna, in many cases simultaneously. These strategies included commitments to avoid siting of new oil and gas exploration or production activities outside of protected areas or areas (BP, 2020; Shell, 2020; Total, 2020), and/or specifically monitoring these sites (Equinor, 2020; Petrobras, 2020), e.g. monitoring "interactions with protected areas" by "crossing information from our operations with the data from the World Bank for Protected Areas" from UNEP-WCMC (Petrobras, 2020, pg. 135), or piloting UNEP-WCMC's "methodology for biodiversity indicators for site-based impacts" (Equinor, 2020, pg. 44). Multiple firms reported developing biodiversity plans for the entire firm (Saudi Aramco, 2020), e.g. based on the application of "the mitigation hierarchy, a decision-making framework that involves a sequence of four key actions: avoid, minimize, restore and offset" (Shell, 2020, pg. 55), or similarly a framework based on "prevention, minimization, recovery and compensation of impacts" (Petrobras, 2020, pg. 120), or in another case a firm-wide strategy based on: (i) "voluntary exclusion zones" in protected or sensitive areas, (ii) biodiversity action plans for any new projects located in protected areas, and (iii) biodiversity action plans for existing sites in "environmentally significant sites", with a goal to prepare plans for projects located in protected areas or on sites "which are major to the environment"… "by 2025 at the latest and deployed by 2030" (Total, 2020, pg. 245). Similarly, a firm focused on developing plans for each site, with a goal of "100% of (…) installations with a biodiversity action plan by 2025", with standards for biodiversity action plans that "must consider the mapping of protected and sensitive areas, the characterization of biodiversity, impact assessments, preventive measures, minimization, recovery and monitoring programs, as well as fauna and flora management actions, among other actions" (Petrobras, 2020, pg. 135).

In addition to firm-wide strategies, several described specific initiatives for the protection of designated marine areas, e.g. establishment of a "63km^2 Mangrove Eco-Park Eastern Province" (Saudi Aramco, 2019, pg. 81), Niger River Delta (Shell, 2020), or targeted restoration efforts, e.g. artificial reefs, coastal and shoreline erosion protection (Qatar, 2020), mangrove restoration or planting "along the Arabian coastline" (5.3 million mangroves reported) (Saudi Aramco, 2019, pg. 81), or for sites that stop operations, "considering the development of a dedicated area rich in biodiversity (e.g. rare species habitats, biodiversity sanctuaries, etc.) as one of the options for its rehabilitation" (Total, 2020, pg. 245), or restoration "where our operations have had an impact" (Shell, 2020, pg. 55) or "degraded areas" (Petrobras, 2020). One firm noted that it had an "ocean action line" of projects focusing on marine and coastal biodiversity, including the number of "fauna species threatened with extinction" (Petrobras, 2020, pg. 140).

Finally, firms described efforts to monitor biodiversity more broadly, e.g. installing measurement instruments on the seabed in Norway for an "ocean observatory" providing data on "marine processes" and "marine ecosystems", e.g. on cold-water corals (Equinor, 2020, pg. 44), "marine eco-surveys" conducted every 3 years "to assess the environmental impacts from our offshore oil and gas facilities, and invest in initiatives to protect wildlife and enhance biodiversity in Qatar" (Qatar, 2019, pg. 56), or through "mapping of protected and sensitive areas", use of "georeferenced environmental databases" and production of an "Annual Biodiversity Report" (Petrobras, 2020, pg. 135).

Firms also mentioned efforts to monitor species potentially affected by operations, e.g. sea turtles (Qatar, 2019), "species in habitats located in areas influenced by our operations", those "vulnerable", "in danger", "in critical danger" according to either "national list" or "international list (IUCN)" (Petrobras, 2020, pg. 138), and marine mammals, for example "through the deployment of passive acoustic monitoring stations" in a field in the southwestern area of the Barents sea, and the "use of two real-time passive acoustic buoys" to monitor for the presence of North Atlantic right whales in the "Empire Wind lease area in the US", as well as tests to "evaluate the effectiveness of thermal imaging technology for monitoring the presence of large whales and sea turtles in periods of poor visibility…[providing] the potential to digitalize marine mammal monitoring and reduce the number of people needed offshore compared to traditional human observations" (Equinor, 2020, pg. 44).

Finally, to address the introduction of non-native species, one firm referenced support for the Ballast Water Management Convention (Qatar, 2019), while another described efforts to prevent the spread of "the invasive sun coral" in Brazil through the development of a "risk tool…to assess the potential of spreading from vessels operating in the field" (Equinor, 2020, pg. 44).

***

5. OFFSHORE WIND

Most frequently mentioned impacts (Box S12). All nine firms reviewed referenced their energy utilization and greenhouse gas emissions, while seven referenced some type of oceanic pollution, five mentioned noise pollution, two cited end-of-life impacts of materials, and one referenced oil spills. In terms of oceanic pollution, several firms reported on both hazardous and non-hazardous waste generation and disposal, though the reports were not clear on whether the source was from an ocean-based activity (EON, 2020; Iberdola, 2020; NPI, 2020 and Siemens 2020). While multiple firms described efforts to address noise pollution, relatively few mentioned plastic pollution. Finally, in terms of end-of-life impacts, Orsted (2020, pg. 17) noted that wind turbine blades "continue to be difficult to recycle" and "while some technologies exist, scalable solutions are not yet available at a competitive price."

In terms of other direct effects on biodiversity, six firms referenced alteration of habitats, two cited collisions with fauna, and none mentioned the introduction of non-native species. Some firms explicitly referenced marine biodiversity, for example in the context of SDG 14 (Orsted, 2020). More broadly, Orsted (2020, pg. 22) stated that the firm had "started work to systematically address how we manage impacts on biodiversity, focusing first and foremost on our offshore wind activities."

Box S12. Examples of ocean impacts cited by offshore wind energy firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from "offshore logistics", e.g. from vessels running on fossil fuels.

Oceanic pollution

- Noise pollution: installation of wind turbines (offshore piling).
- End-of-life impacts: from disposal of wind turbine blades.
- Other oceanic pollution: waste pump water.

Other direct impacts on biodiversity

- Alteration of habitats and collisions with fauna: from location of wind farms, notably near areas of high biodiversity or marine protected areas.

Types of goals set to address ocean impacts (Box S13). All nine companies reported on their greenhouse gas emissions, with the data being rarely disaggregated between emissions from offshore[4] and onshore wind operations (although NPI and Orsted disaggregated emissions accordingly). Multiple firms articulated net-zero or carbon neutrality goals by different dates, typically for both onshore and offshore wind operations, while many simultaneously mentioned that broader societal goals for decarbonization were expected to drive current and future offshore wind energy production, e.g. Vattenfall (2020, pg. 36) stated that "offshore wind could become the backbone of the envisaged hydrogen economy, and thanks to its high number of full-load hours it is particularly well suited for the production of fossil-free hydrogen."

[4] For example greenhouse gas emissions from the manufacturing, transport and installation of offshore wind turbines, their foundations, and substations and cables (Orsted, 2020).

While relatively few goals were set for other types of pollution, firms mentioned broad goals for marine biodiversity conservation, inclusive of multiple impacts on species or ecosystems (e.g. species displacement, collisions with fauna, removal of biomass). For example, Orsted (2020, pg. 23) reported that in addition to addressing negative environmental impacts, the company was “also exploring the potential for offshore wind farms to support marine wildlife.”

Box S13. Examples of goals set by offshore wind firms for addressing ocean impacts

Climate change

- Iberdola (2020, pg. 77) “Iberdola firmly believes that the transition to a carbon-neutral economy by 2050 is possible and makes economic sense.”
- Orsted (2020, pg. 8) “We are now on track to becoming carbon-neutral in our energy generation and operations by 2025, making us the first major energy company to transform from fossil fuels and reach net-zero emissions.”

Other direct impacts on biodiversity

- Iberdola (2020, pg. 108): stated goal for new facilities to deliver a “net positive impact on biodiversity”, and to “preserve marine ecosystems through innovative measures in the construction and operation of offshore wind farms”.
- Vattenfall (2020, pg. 160): “we have set a 2030 ambition to be a recognised leader in biodiversity management. A core component of this work is to adopt a Net Positive Impact approach. This means we will further safeguard biodiversity by going beyond the "no net loss" approach and implementing biodiversity

Strategies described to address ocean impacts. As one example of the types of greenhouse gas emission reduction strategies described in the reports, Orsted (2020, pg. 8) stated that if the company was not able to meet carbon neutrality goals through the use of renewable energy (e.g. for offshore logistics), the firm would “plan to invest in carbon-removal projects that are verified and certified.” In terms of noise pollution, Longyuan (2020, pg. 154) reported that the firm had “studied the influence of wind turbine noise on marine and land animals and monitored for a long time”, while Orsted (2020, pg. 18) described the use of a “bubble curtain, a long circular tube releasing a dense curtain of bubbles surrounding the turbine foundation….[that] can reduce the sound waves spreading within the seabed and water”, as an example of technology to reduce noise from installing wind turbine foundations in the seabed, also referenced by NPI (2020) and Vattenfall (2020). For other types of oceanic pollution such as wastewater, Iberdola (2020, pg. 54) referenced the “installation of a floating base to actively collect waste pump water.”

For other direct impacts on marine biodiversity, such as from alteration of habitats and collisions with fauna, Iberdola (2020, pg. 108) described a review process to avoid installing wind farms in locations within or adjacent to “areas of special interest for biodiversity without a specific designated protection” or marine protected areas (e.g. World Heritage Sites, “national or regional protected areas” and “the relevant categories defined by IUCN”), “unless there are no feasible alternatives”, as well as understanding species near facilities that are on the IUCN Red List. NPI (2020, pg. 40) similarly reported on “operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.” Both Orsted (2020) and Vattenfall (2020) referenced the potential of wind turbine foundations to function as artificial reefs, and Orsted (2020) described the potential for cables to create additional habitats for fauna. Orsted (2020, pg. 37) also mentioned participating in the “Offshore Coalition for Energy and Nature, a multi-stakeholder group working to further the coexistence of offshore wind with marine industries and healthy marine ecosystems.”

***

6. PORT ACTIVITIES

Most frequently mentioned impacts (Box S14). All ten firms reviewed referenced their energy utilization and greenhouse gas emissions, while all firms also mentioned some type of oceanic pollution, typically wastewater or solid waste, though in some cases specifying plastic waste. Additionally, in terms of pollution, three firms referenced oil spills or gas leaks, e.g. oil spills at terminals, while two cited noise pollution and two referenced end-of-life impacts. For example, one firm noted that "the increase in underwater noise from human activity is of growing concern" (APM Terminals, 2020, pg. 39), while another mentioned "minimizing noise emission" to be material (Hamburger, 2020, pg. 177) and a third identified noise pollution in 2020 to be a "potential material topic" (Tianjin, 2020, pg. 23).

Regarding other direct effects on biodiversity, fewer firms referenced these impacts as material: five mentioned alteration of habitats and two referenced the introduction of non-native species. Examples of broader statements included that a firm was "conscious of the potential impact on marine biodiversity from development and construction projects, as well as ongoing terminal operations and maintenance, that we may undertake with local port authorities" (PSA, 2020, pg. 55), conducted "marine ecological monitoring and investigation" at its ports (China Merchants Group, 2020, pg. 59), or had "been pursuing an active policy to manage its impact on biodiversity" (Bollore, 2020).

Box S14. Examples of ocean impacts cited by port activity firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from ports, e.g. from port equipment operations and from electricity consumption at ports, as well as self-owned fleets, and in some cases reporting on Scope 3 emissions from transport.

Oceanic pollution

- Oil spills and gas leaks: oil spills at port terminals.
- Noise pollution: noise levels in port areas.
- End-of-life impacts: from self-owned transport vessels.
- Other oceanic pollution: waste (solid waste, wastewater), in some cases specifying plastic waste.

Other direct impacts on biodiversity

- Alteration of habitats: from location, construction and operation of port terminals, with at least two firms referring to the role of ports in illegal trade in endangered species (according to the Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES).
- Introduction of non-native species: from discharge of ballast water.

Types of goals set to address ocean impacts (Box S15). In terms of energy utilization, while all firms reported on their greenhouse gas emissions, in some cases the data were not disaggregated between port activities and other activities unrelated to the blue economy (e.g. terrestrial transport and logistics services). All firms reported on Scope 1 and 2 emissions, but for those reporting on Scope 3 it constituted the majority of emissions, e.g. from transport services (Bollore Group, 2020). Several firms articulated some form of net zero emissions goal, typically by 2050 (China Merchants Group, 2020; DP World, 2020; Hamburger, 2020; PSA, 2020), with six firms articulating measurable goals (targets). Beyond climate, several firms reported measurable goals for pollution from waste, e.g. to develop waste reduction plans (PSA, 2020), or to eliminate the use of specific plastic items (DPW, 2020). Finally, in terms of end-of-life impacts, one firm articulated an ambition to "creat[e] opportunities globally" for responsible ship recycling (APM, 2020, pg. 32). Beyond climate change and pollution, relatively few measurable goals were mentioned by port activity firms for addressing other direct impacts on biodiversity (e.g. introduction of non-native species, alteration of habitats, etc.), although one firm described a goal of developing "an action plan for 2025 and internal monitoring" of efforts to combat the illegal trade in endangered species (Bollore, 2020, pg. 21).

Box S15. Examples of goals set by port activity firms for addressing ocean impacts

Climate change

- DP World (2020, pg. 3): "committed to a zero carbon future by 2050".
- Hamburger (2020, pg. 18): goal to "halve absolute CO2 emissions by 2030" and "aiming to become climate-neutral by 2040".
- PSA (2020, pg. 17): set targets to "reduce scope 1 and 2 carbon emissions by 50% by 2030, and by 75% by 2040 [compared to 2019 as baseline]", and "ultimately we aim to achieve net zero emissions by 2050 as a group". Also aiming for 90% of rubber-tyred gantry cranes to be electric or hybrid by 2030.

Oceanic pollution

- Other types of oceanic pollution:
  - Waste: PSA (2020, pg. 57): Aims to "establish a global waste reduction and recycling plan by 2023".
  - Plastic waste: DPW (2020, pg. 67): target to "achieve zero single-use plastic bottles by 2023".

Strategies described to address ocean impacts. Multiple firms cited plans for emissions reductions (APM Terminals, 2020; PSA, 2020), with the strategies most frequently focusing on increasing the energy efficiency of port operations, e.g. by converting diesel-powered container handling equipment to electric or diesel-battery hybrids (e.g. rubber-tyred gantry cranes, quayside container cranes, internal tractors such as "conventional diesel terminal tractors", etc.). For example, one firm noted that "over 80% of a port's energy consumption relates to the fuel and electricity consumed by container handling equipment (forklifts, [rubber-tyred gantry cranes], quayside container cranes, and internal tractors, for example) and terminal vehicles (shuttle buses and passenger vehicles, for example)" (CKHH, 2020, pg. 31). Additionally, multiple firms cited plans to increase shore-based power supply to vessels at ports (China Merchants Group, 2020; SIPG, 2020; Tianjin, 2020). More broadly, some firms referenced "green" or "smart" ports (China Merchants Group, 2020; SIPG, 2020), e.g. stating that "green and low-carbon ports are created to boost global climate governance" (China Merchants Group, 2020, pg. 97).

For oceanic pollution from waste, including in some cases plastic waste, several firms described a focus on treating wastewater at port facilities and reporting on waste generation (solid waste, oil/sludge, wastewater, etc.) (China Merchants Group, 2020; Hamburger, 2020; ICTS, 2020; PSA, 2020; Tianjin, 2020). Additionally, several firms reported efforts to reduce plastic waste from single-use plastics at port terminals (Bollore, 2020), or increasing recycling of plastic bottles (PSA, 2020). For end-of-life impacts from vessels, APM Terminals (2020, pg. 33) referenced the Hong Kong Convention for ship recycling and committed to participate in "the Ship Recycling Transparency Initiative…[which]…seeks to accelerate a voluntary, market-driven approach to responsible ship recycling practices, with today 11 shipowners disclosing."; and to "create opportunities for responsible ship recycling of post-panamax ships globally". The firm described an engagement strategy to support the transformation of the ship-breaking industry based in Alang, India (APM Terminals, 2020). Firms that referenced noise pollution described efforts to monitor "the noise level in port areas…ensuring that they meet the GB3096-2008 Environmental Quality Standard for Noise" (Tianjin, 2020, pg. 43), or that "a positive bi-product of some of our energy efficiency retrofits of vessels is that the level of ship noise is lowered (…) We sail at slower speeds in areas where [orca] whales have been identified" (APM Terminals, 2020, pg. 39).

In terms of other direct impacts on biodiversity, at least three firms mentioned efforts to address the role of ports in facilitating illegal trade of endangered species, e.g. as "part of a transport industry taskforce to help eliminate illegal wildlife trade" (DP World, 2020, pg. 64), or acting to increase monitoring ("educating employees to best inform customers and promote best practices, external partnerships, data processing and sharing") "under the Biodiversity Charter and its individual commitments in the act4nature France initiative" (Bollore, 2020, pg. 21), as well as signing the 'United for Wildlife Buckingham Palace Declaration' (Bollore, 2020; Hutchison Ports, 2020). In addition to the illegal trade in endangered species, several firms referenced efforts to support area-based conservation, e.g. at specific ports (China Merchants Group, 2020; Hutchison Ports, 2020) or through the implementation of "an action plan in 100% of the 35 sites with ecological potential by 2025 (…) drawn from biodiversity footprint study of 81 priority sites carried out in 2016" (Bollore, 2020, pg. 113). Additionally, one firm noted a strategy based on investing in "ocean restoration projects", having developed an "Ocean Restoration Toolkit (…) for our global business units to implement" (DP World, 2020, pg. 67). Finally, two firms referenced efforts to increase ballast water treatment systems on self-owned vessels, e.g. in support of the IMO Ballast Water Management guidelines (ICTS, 2020) and the "Ballast Water Management Convention" which "obligates [the] shipowner to have ballast water systems installed on all vessels by 2024" (APM Terminals, 2020, pg. 39).

***

7. SEAFOOD

Most frequently mentioned impacts (Box S16). Removal of biomass was the ocean impact cited by the most firms reviewed (eight of the nine), followed by greenhouse gas emissions and other forms of oceanic pollution (seven firms each). Two firms referenced pollution from oil spills and gas leaks and one from the end-of-life impacts of fishing gear. In terms of other direct impacts on marine biodiversity (beyond removal of biomass), five firms referred to the alteration of habitats, and two to the introduction of non-native species.

Box S16. Examples of ocean impacts cited by seafood firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from seafood production, Scope 3 emissions, from operations along the seafood supply chain.

Oceanic pollution

- Oil spills and gas leaks: oil spills from fishing vessels.
- End-of-life impacts: from fishing gear.
- Other oceanic pollution: waste (solid waste, wastewater), notably plastic used in operations, medicines/anti-biotics used in aquaculture farms, as well as organic waste from farms (fish feed, feces).

Other direct impacts on biodiversity

- Removal of biomass: illegal and unsustainable fishing to produce wild-caught seafood, provide feed for aquaculture.
- Alteration of habitats: from disturbance of the seabed under aquaculture pens, from escaped fish in aquaculture pens.

Types of goals set to address ocean impacts (Box S17). Five of the nine firms reviewed set measurable goals for greenhouse gas emissions, five for different forms of oceanic pollution from seafood production operations (e.g. plastic pollution), including one for oil spills and gas leaks specifically, and four for the removal of biomass (e.g. sustainable fishing).

Strategies described to address ocean impacts. Most firms reported on Scopes 1 and 2 emissions, with only one firm measuring emissions intensity along different stages of the seafood supply chain (Mowi, 2020). Strategies described by firms to address greenhouse gas emissions from energy utilization largely focused on increasing energy efficiency at seafood production facilities (Dongwon, 2020; Maruha Nichiro, 2020; Mowi, 2020; Nippon Suisan Kaisha, 2020; Thai Union, 2020), e.g. converting from fluorescent lighting to LED bulbs at "production sites and elsewhere"; increased efficiency in "boiler and compressor operation", switching to "non-CFC freezers at distribution centers in Japan", scheduling changes to reduce electricity usage for lighting and air conditioning, insulating pipes (Maruha Nichiro, 2020, pg. 25), and increasing the use of renewable electricity (Mowi, 2020; Thai Union, 2020), e.g. from installation of solar panels on unused factory rooftops (Thai Union, 2020). One firm described a strategy focused on reductions at different stages of the seafood supply chain in aquaculture, from feed (increasing energy efficiency of feed plants, optimal feed conversion ratio, ensuring "deforestation-free soy"), farming (using land power and hybrid to replace diesel generators for farm sites, increasing renewable electricity to freshwater sites and processing plants); and sales and marketing (optimized logistics, more "climate-friendly supply chain" and efficiency in processing plants) (Mowi, 2020). Additionally, one firm reported on emission reduction goals and strategy across all operations (motivated in part by the expectation of future regulation), but not specific to seafood production activities (Mitsubishi, 2020).

Box S17. Examples of goals set by seafood firms for addressing ocean impacts

Climate change

- Maruha Nichiro (2020, pg. 25): set goal to "reduce CO2 emissions per unit of sales by more than 4% from FY17 to FY21".
- Mowi (2020, pg. 26): reports aproved SBTi targets to "reduce absolute scope 1 and 2 GHG emissions by 35% by 2030 and by 72% by 2050 (2016 base year)" and to "reduce absolute scope 3 GHG emissions by 35% by 2030 and by 72% by 2050 (2018 base year)".
- Nippon Suisan Kaisha (2020, pg. 20): target for CO2 emissions of "15% reduction in fiscal 2030 compared to fiscal 2015 (per unit)".
- Thai Union (2020, pg. 11): states goal "to double [company's] energy productivity by 2041, from a 2016 baseline".

Oceanic pollution

- Maruha Nichiro (2020, pg. 27): states a goal to "reduce waste and improve recycling rate", describes waste reduction, a target of achieving "a 99% waste recycling by FY2021".
- Mowi (2020, pg. 48): aims to achieve "responsible use of plastics", with targets to by 2025: (i) "100% of our plastic packaging will be reusable, recyclable or compostable"; (ii) "at least 25% of plastic packaging will come from recycled plastic content"; and (iii) "100% of farming plastic equipment is reused or recycled".
- Nippon Suisan Kaisha (2020, pg. 19): set a goal of "zero plastic emissions into the marine environment".
- Thai Union (2020, pg. 11): set goal that "by 2025, 100 percent of our branded packaging will be reusable, recyclable or compostable, and that we will also have an average of 30 percent recycled content in our branded packaging."

Removal of biomass

- Maruha Nichiro (2020, pg. 28): states a goal to "promote certification acquisition for sustainable fishing and farming" and "strengthen efforts to abolish illegal, unreported an unregulated (IUU) fishing".
- Nippon Suisan Kaisha (2020, pg. 28): states a goal to procure sustainable wild-caught seafood, "aiming to have the items the Nissui Group procures confirmed as sustainable by the year 2030.
- Thai Union (2020, pg. 100): describes a "tuna commitment" to "achieve a minimum of 75 percent of our own brands of tuna coming from fisheries that are Marine Stewardship Council certified, or in a Fisheries Improvement Project. (FIP) by the end of 2020."

In terms of oceanic pollution, some firms reported on monitoring different forms of waste, e.g. organic solids (fish feed and feces) in aquaculture operations (Mowi, 2020; Nippon Suisan Kaisha, 2020), or solid waste and wastewater generally (Dongwong, 2018; Mowi, 2020; Nippon Suisan Kaisha, 2020; Thai Union, 2020). Multiple firms described efforts to address plastic pollution from their operations, including addressing the recyclability and recycled content in "branded" single-use packaging in seafood products (Thai Union, 2020), developing lighter-weight plastic packaging material and recyclable packaging (Maruha Nichiro, 2020; Mowi, 2020; Dongwon, 2018), increasing the recycling of plastic used (Mowi, 2020; Dongwon, 2018), focusing on packaging "redesign/simplification" (Mowi, 2020), using recycled PET (Mowi, 2020), and assessing the baseline of company plastics use and leakage (Nippon Suisan Kaisha, 2020). Additionally, one firm reported introducing "a comprehensive monitoring program related to microplastics (…) in our fish", e.g. salmon, to "understand what impact microplastic can have for our value chain" (Mowi, 2020, ps. 88). Finally, several firms described efforts to address the end-of-life impacts of fishing gear, often comprised of plastic material, including supporting the Global Ghost Gear Initiative (Maruha Nichiro, 2020; Mowi, 2020; Thai Union, 2020), surveying vessel owners to help develop a strategy for such gear that includes education of vessel owners and captains, research to identify improvements to help recover gear, and incentives for collaboration by fishers (Thai Union, 2020), and participating in "international coastal cleanup campaigns" (Marahu Nichiro, 2020, pg. 107).

To address the removal of biomass from the oceans, firms most frequently described strategies based on purchasing or producing wild-caught seafood independently certified as sustainable, e.g. with an eco-label like the Marine Stewardship Council (Maruha Nichiro Corporation, 2020; Nippon Suisan Kaisha, 2020; Thai Union), or a GSSI-recognized standard (Mowi, 2020). One firm described this strategy in terms of tri-annually surveying the sustainability status of wild-caught seafood procured, with those categorized as "not healthy" or "no information" further surveyed to confirm if the national government or regional fisheries management body has a recovery plan, whether seasonal restrictions existed, and whether "any fisheries management existed" (Nippon Suisan Kaisha, 2020, pg. 30).

In addition to pursuing and reporting on eco-labels for sustainably-sourced seafood, firms described a strategy to address the removal of ocean biomass, based on enhancing supply chain transparency ("traceability") (Nippon Suisan Kaisha, 2020; Thai Union, 2020), e.g. working towards ensuring traceability of products when no fisheries management can be confirmed or eco-label issued (Nippon Suisan Kaisha, 2020). As part of enhanced transparency in supply chains, one firm reported publicly disclosing "global supply chain data" (e.g. area of fish catch, area of production, fishing gear used, sustainability certification and ratings) through "the Ocean Disclosure Project", as well as signing the "World Economic Forum's Tuna Traceability Declaration that aims to stop IUU tuna from entering supply chains" (Thai Union, 2020, pg. 94). Supply chain transparency in this instance was described as a strategy both to help ensure wild-caught seafood is sourced from sustainably managed fisheries, and to combat IUU fishing, and the subject of a range of investments, including installation of "electronic observer (e-observer) systems on vessels…, which harness cameras and sensors to monitor practices on-board the boats", together with technologies such as artificial intelligence to help analyze the recorded observations, and "Fishcoin, a blockchain-powered ecosystem that rewards accurate catch reporting with cryptocurrency" (Thai Union, 2020, pg. 10). Finally, to support advancing seafood supply chain transparency more broadly, one firm mentioned supporting "the Global Dialogue on Seafood Traceability to develop key data elements and interoperability for the seafood industry" (Thai Union, 2020, pg. 92). Another strategy reported by at least one seafood firm to address the removal of biomass was the efficiency of using wild-caught seafood to "feed" aquaculture operations, in terms of 'fish-in, fish-out (FIFO)', including the species and source fishery for feed, the volume purchased, and for farms the percentage of wild-caught material used per unit of feed (e.g. the 'forage fish dependency ratio'), as compared to the standard set by the Aquaculture Stewardship Council for its eco-label (Mowi, 2020).

Finally, in terms of direct alteration of habitats, one firm reported addressing disturbance of the seabed under aquaculture pens based on benthic surveys and "corrective action" as needed, including "stopping or reducing production, repositioning the pens and/or increasing the fallow period, i.e. the time between production cycles, to allow the seabed time to recover from organic loading" (Mowi, 2020, pg. 65). More broadly, another firm stated that it aimed to "protect marine resources" (Maruha Nichiro, 2020, pg. 28), and several firms reported strategies to increase the volume of seafood farmed through aquaculture that is eco-labelled or certified as sustainable by the Aquaculture Stewardship Council.

***

8. SHIPBUILDING AND REPAIR

Most frequently mentioned impacts (Box S18). Nine of the ten firms reviewed referenced their energy utilization and greenhouse gas emissions, and nine also referenced some type of oceanic pollution, largely in terms of wastewater and solid waste. Additionally, three firms referenced the end-of-life impacts of vessels built. In terms of pollution, three firms referenced noise pollution and two mentioned oil spills and gas leaks. Relatively few firms referred to impacts on biodiversity in their reporting, with two firms citing the introduction of non-native species, and one the alteration of habitats.

Box S18. Examples of ocean impacts cited by shipbuilding and repair firms

Climate change

- Energy utilization: Scopes 1 and 2 GHG emissions from operations, and energy efficiency of vessels designed and built.

Oceanic pollution

- Oil spills and gas leaks: oil spills from vessels built, and from shipyards.
- Noise pollution: from “coastal works” and maritime traffic.
- End-of-life impacts: from vessels built, shipyard materials.
- Other oceanic pollution: waste (solid waste, wastewater).

Other direct impacts on biodiversity

- Alteration of habitats, species displacement: location of shipyards.
- Introduction of non-native species: ballast water discharged from vessels built.

Types of goals set to address ocean impacts (Box S19). Only four firms set measurable goals for energy utilization and greenhouse gas emissions, and none had measurable goals for any of the other ocean impacts referenced.

Box S19. Examples of goals set by shipbuilding and repair firms for addressing ocean impacts

Climate change

- BAE (2020, pg. 35): set goal of net zero emissions “across our operations” by 2030, and “a net zero value chain” by 2050.
- Fincanteiri (2020, pg. 153): states a goal for a “50% reduction of scope 2 emissions by 2022, compared to 2017”.
- Samsung Heavy Industries (2020, pg. 38): “aims to build non-carbon ships, going beyond carbon-free ships”, and states a goal of carbon neutrality by 2050, and a goal of “achieving 70% eco-friendly orders by 2025”.

Strategies described to address ocean impacts. Multiple firms focused on the design, or ‘eco-sustainable design’ (Fincanteiri, 2020) (Box S20), of more energy-efficient vessels (China Shipbuilding, 2020; DSME, 2020; Fincanteiri, 2020; Hyundai Heavy Industries, 2020; Samsung Heavy Industries, 2020), including vessels using alternative fuels such as LNG or hydrogen fuel cells (China Shipbuilding, 2020; Fincanteiri, 2020; Hyundai Heavy Industries, 2021), ‘electric propulsion’ (Hyundai Heavy Industries, 2021), ‘sailing efficiency improvement’ (Hyundai Heavy Industries, 2021), “fan coil installation in cabins, fan coil installation in public areas, variable speed adjustment systems for electric motors, heat recovery system optimization, recalibration of drinking water generation system, increase of electric motor energy class, LED and high-efficiency lighting and automatic lighting control" (Fincanteiri, 2020, pg. 170). Additionally, some firms referenced efforts to start measuring designed/built vessels' carbon footprint (Naval Group, 2020), as well as energy efficiency in shipyards (BAE, 2020).

In terms of addressing the end-of-life impacts of materials such as built vessels, at least one firm described an effort to design cruise vessels to minimize end-of-life impacts, obtaining voluntary certifications that included a commitment "to provide, on delivery of the ship, the list of hazardous materials in accordance with the Hong Kong Convention for the safe and environmentally friendly recycling of ships" (Fincanteiri, 2020, pg. 173). Similarly, the firm stated that "all naval vessels are also delivered with a Green Passport (…) an inventory of materials to be monitored during the ship's life cycle (…) used to ensure that it is scrapped safely and in an environmentally friendly way" (Fincanteiri, 2020, pg. 175). Additionally, some firms referenced investments in shipyards and the materials used (BAE, 2020), e.g. "smart shipyards" (Hyundai, 2020).

Box S20. Intentions to design vessels to reduce greenhouse gas emissions and promote the circular economy

One firm reported that "the world of navigation, whether cruise, merchant or naval, is going through a process of evolution under the principles of sustainability and the circular economy (…) The ships under construction will increasingly resemble a large, hyper-connected, energy self-sufficient, lighter and green or hybrid propellant floating city, capable of recycling up to 90% of the waste produced" (Fincanteiri, 2020, pg. 149).

In terms of addressing other oceanic pollution, several firms describe efforts for hazardous waste management in the shipbuilding process (China Shipbuilding, 2020; Huntington, 2020; Fincanteiri, 2020; Samsung Heavy Industries, 2020), and wastewater treatment at shipyards (DSME, 2019; Fincanteiri, 2020; Samsung Heavy Industries, 2020), as well as investments in recycling to reduce waste at a shipyard (General Dynamics, 2020). For example, one firm reports that it "built our own Tele-Monitoring System in our ocean-discharged wastewater treatment facilities to analyze the concentration of pollutants in real time" (Samsung Heavy Industries, 2020, pg. 47). Another reports on efforts to design naval vessels to collect and store pollutants on board, as well as more efficiently treat wastewater (Fincanteiri, 2020).

Firms describe relatively little in terms of strategies to address other direct impacts on biodiversity, though one case emphasizes "safeguarding the natural values of the areas surrounding the shipyards", which includes several located near marine protected areas or UNESCO sites for example (Fincanteiri, 2020, pg. 167).

***

Supplementary References. Key references in Supplementary Table 1.

1. Hall, C. M. Trends in ocean and coastal tourism: The end of the last frontier? *Ocean Coast. Manag.* **44**, 601–618 (2001).

2. Brida, J. G. & Zapata, S. Cruise tourism: economic, socio-cultural and environmental impacts. *Int. J. Leis. Tour. Mark.* **1**, 205 (2010).

3. Tourism and Recreation. in *The First Global Integrated Marine Assessment* (ed. United Nations) 425–440 (Cambridge University Press, Cambridge, 2017). doi:10.1017/9781108186148.030.

4. Gössling, S., Hall, C. M. & Scott, D. Coastal and Ocean Tourism. in *Handbook on Marine Environment Protection : Science, Impacts and Sustainable Management* (eds. Salomon, M. & Markus, T.) 773–790 (Springer International Publishing, Cham, 2018). doi:10.1007/978-3-319-60156-4_40.

5. GESAMP. *CG 5: Sand and Gravel Mining in the Marine Environment – New Insights on a Growing Environmental Problem*. (2019).

6. Kark, S., Brokovich, E., Mazor, T. & Levin, N. Emerging conservation challenges and prospects in an era of offshore hydrocarbon exploration and exploitation. *Conserv. Biol.* **29**, 1573–1585 (2015).
7. Offshore Hydrocarbon Industries. in *The First Global Integrated Marine Assessment* (ed. United Nations) 333–352 (Cambridge University Press, Cambridge, 2017). doi:10.1017/9781108186148.024.

8. Sommer, B. *et al.* Decommissioning of offshore oil and gas structures – Environmental opportunities and challenges. *Sci. Total Environ.* **658**, 973–981 (2019).

9. Bailey, H., Brookes, K. L. & Thompson, P. M. Assessing environmental impacts of offshore wind farms: Lessons learned and recommendations for the future. *Aquat. Biosyst.* **10**, 1–13 (2014).

10. Taormina, B. *et al.* A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renew. Sustain. Energy Rev.* **96**, 380–391 (2018).

11. Best, B. D. & Halpin, P. N. Minimizing wildlife impacts for offshore wind energy development: Winning tradeoffs for seabirds in space and cetaceans in time. *Plos One* **14**, e0215722 (2019).
12. Martínez, M. L. *et al.* A systemic view of potential environmental impacts of ocean energy production. *Renew. Sustain. Energy Rev.* **149**, (2021).

13. Galparsoro, I. *et al.* Reviewing the ecological impacts of offshore wind farms. *Npj Ocean Sustain.* **1**, 1 (2022).

14. ESCAP. *Assessment of the Environmental Impact of Port Development: A Guidebook for EIA of Port Development*. https://www.unescap.org/resources/assessment-environmental-impact-port-

development-guidebook-eia-port-development (1992).

15. Trozzi, C. & Vaccaro, R. Environmental impact of port activities. *WIT Trans. Built Environ.* **51**, (2000).

16. EPA. Ports Primer: 7.1 Environmental Impacts. (2023).

17. Crowder, L. B. *et al.* The Impacts of Fisheries on Marine Ecosystems and the Transition to Ecosystem-Based Management. *Annu. Rev. Ecol. Evol. Syst.* **39**, 259–278 (2008).

18. Parker, R. W. R. *et al.* Fuel use and greenhouse gas emissions of world fisheries. *Nat. Clim. Change* **8**, 333 (2018).

19. Gephart, J. A. *et al.* Environmental performance of blue foods. *Nature* **597**, 360–365 (2021).

20. Naylor, R. L. *et al.* A 20-year retrospective review of global aquaculture. *Nature* **591**, 551–563 (2021).

21. OECD. *Council Working Party on Shipbuilding (WP6), "Environmental and Climate Change Issues in the Shipbuilding Industry."* https://one.oecd.org/document/C/WP6(2010)10/En/pdf (2010).
22. Andersson, K. J. *et al. Shipping and the Environment*. (2016).

23. Pirotta, V., Grech, A., Jonsen, I. D., Laurance, W. F. & Harcourt, R. G. Consequences of global shipping traffic for marine giants. *Front. Ecol. Environ.* **17**, 39–47 (2019).

24. Walker, T. R. *et al.* Environmental effects of marine transportation. in *World Seas: An Environmental Evaluation* 505–530 (Elsevier, 2019).