Structures spread across our seas

Hawkins, SJ

10.1038/s41893-020-00598-y
Nature Sustainability
Springer Science and Business Media LLC

Pre-proof accepted version of Hawkins, S.J., Firth, L.B. and Evans, A.J., 2021. Structures spread across our seas. Nature Sustainability, 4: 7-8.

Strapline: Ocean sprawl

Title: Structures spread across our seas

Construction along coasts and offshore is accelerating. A new study estimates the extent of different developments and their wider influence and forecasts their expansion.

Stephen Hawkins, Louise Firth and Ally Evans

Ocean sprawl [1] evokes well the relentless spread of the built environment along the planet's coastlines, now plunging into deeper waters. Most of the world's recent and projected population growth is along coastlines, driving urbanization through homes, industry and transport in a defended zone simultaneously squeezed by rising and stormier seas[2]. Oil and gas exploitation went offshore 100 years ago and now occurs in ever-deeper waters. Renewable energy generation is rapidly expanding in shallow waters and will move further offshore with floating wind turbines. Aquaculture has expanded from enclosed to open waters. Deep-sea mining is next. But the alarming expansion of the built environment across our seas often passes unnoticed given deserved attention to anthropogenic climate change and overfishing and the visual reality that much is "out of sight." On pages xxx of this issues, Bugnot et al[3] provide a timely inventory of the current extent of such marine built structures and and forecast their likely spread.

Marine artificial structures modify and even destroy habitat and change the surrounding ecology. As on land, many habitats are literally paved over. On soft muddy and sandy seabeds, structures generate islands of artificial hard habitat[2], which shifts the community from sediment-dwelling animals that import food and recycle nutrients to surface-fouling filter-feeding invertebrates and seaweeds that produce and export material as detritus. The structures attract mobile fish and crabs, which forage around them. Complex rocky reefs are replaced by simple, smooth hard surfaces, often less suitable as marine habitats [2]. Structures can also trap flotsam and jetsam, including unsightly and eventually smelly seaweeds and harmful plastic pollution[4]. Impacts reach further afield too. Local erosion problems can be exported along extensive stretches of coastlines. Seaweed can become strewn far and wide. Perhaps the biggest far-reaching impact is on connectivity: on land structures act as barriers while at sea they can act as stepping-stones for species, especially invasive non-natives[5]. Local piecemeal construction can scale-up insidiously along coastlines, epitomised by the increasingly crowdedNorth Adriatic Coast and a new coastal "Great-Wall" of China[6]**.** As increasingly appreciated in cities, the attendant light, noise pollution and changes in electric fields, as caused by under-sea cables, all influence sensory landscapes and hence animal behaviour many kilometres away[7].

Bugnot et al[3] reveals the extent and breakdown of this sprawl. They find that aquaculture accounts for >70% of the current global footprint, with 40% lying within China's exclusive economic zone (EEZ). Almost half of offshore hydrocarbon production is in the United States' EEZ; whilst most renewable construction is offshore the UK. The far-reaching influence of noise pollution from shipping leads suggests ports are responsible globally for virtually all (>99%) of seascape modification away from structures. They estimate this impacts 1-3 million km^2 insidiously**—**100 times greater than the footprint of the structures themselves. They predict that seascape modification will increase by >50-70% over the next decade.

While Bugnot et al's overview is both revealing and alarming, it is important to recognise the generalisations, assumptions and occasional best guesses needed to compile these statistics, limitations they acknowledge. The severity and reach of impacts in different environments are yet to be fully incorporated, and these could vary substantially. A floating aquaculture-cage in deep, open water will have much less impact that is also reversible impact, as it can be towed away. Land-claim for a major container-port terminal in a sheltered bay, by contrast, is a near-irrevocable switch from sea to land.

Although emptying rapidly, the metaphorical glass can still be considered half-full. Marine structures can have environmental benefits. Increased numbers of filter-feeders can improve water quality in highly-modified enclosed urbanised bays and ports[8] ,helping restore Dock Basins in Liverpool (Fig 1). Wind-turbines arrays (Fig 2) can prevent damage from towed bottom-fishing gear – a widespread impact in shelf seas. Many marine habitats, particularly shallow-water rocks and coarse, mobile sediments, would recover within 5-10 years should a structure be removed. But those with long-lived, habitat-forming species that themselves engineer ecosystems, will recover much more slowly, taking decades (e.g. seagrasses, saltmarshes, mangroves) to centuries (coral or oyster reefs) or longer, even with active restoration[9].

A ray of hope is Marine Spatial Planning (MSP), a framework for managing expansion, siting, zoning and eventual decommissioning of offshore installations in the context of other users and marine life. In the European Union, MSP is a crucial element of the Marine Strategy Framework Directive, partly prompted by foreseen growth of marine renewables[10]. Though embraced increasingly worldwide, MSP must be based on strategic assessment of impacts, both near and far.

Marine life will rapidly colonize (foul) hard structures. Its diversity can be enhanced by building-in or retro-fitting habitat complexity, a process termed eco-engineering. Coastal stakeholders actual favour multi-purpose structures that promote biodiversity and ecosystem services in addition to, for example, their prime function of flood-defence[11]. Using hedges as an analogy: wire or wooden fences are effective but ugly land boundaries; but hedgerows are oases of biodiversity providing multiple goods and services in agricultural landscapes. Eco-engineering of marine structures is best done in already highly modified areas – it should not be used to greenwash habitat destruction when developing in unspoilt blue-field seascapes.

Bugnot et al[3] have diagnosed a fast-spreading, pervasive, pernicious problem. To ensure sustainable seas a precautionary, evidence-based approach to coastal and offshore planning can minimize and even prevent ocean sprawl. We advocate eco-engineering for mitigation and compensation only when and where appropriate.

1 Duarte et al. Front.Ecol.Env. **11,** 91-97(2012)
2 Firth et al. Oceanogr. mar.Biol.ann.Rev. **54**, 189- 262(2016)
3 Bugnot et al. Nat. Sustain, XXXX, (2020).
4 Aguilera et al. Environ. Poll. **214**, 737-747(2016)

5 Bishop et al. J.exp.mar.Biol.Ecol **492,** 7-30(2017)
6 Dong et al. Div.Dist **22,** 731-744(2016)
7 Nagelkerken et al. Oceanogr. mar. Biol.ann.Rev **57,** 229-265(2019)
8 Hawkins et al. Mar.Poll.Bull. https://doi.org/10.1016/j.marpolbul.2020.111150(2020)
9 Bayraktarov et al. Ecological Applications **26,** 1055-1074 (2016)
10 Jones et al. Marine Policy **71**, 256-264 (2016)
11 Evans et al. Env.Sc.Pol. **91**, 60-69(2019)

Figure Legend: Examples of ocean sprawl considered by Bugnot et al. The historic Albert Dock and iconic Liver Building in Liverpool: all built on reclaimed land from 1715 onwards; the Docks at their 1960s peak stretched more than 20 km on either side of the Mersey Estuary. The Albert Dock - redundant for shipping since the 1970s – became the centrepiece of an ambitious urban renewal scheme. Water quality, so essential for redevelopment, is managed by mussel biofiltration and artificial mixing to create a healthy, diverse (inset) but novel cubist ecosystem[8.] One of Antony Gormley's 100 brass statues (*Another Place*) nearby foreshore at Crosby peers out on the Burbo Bank Windfarm; further offshore is the Liverpool Bay Gasfield.

(Suggest panel of two with an inset of marine life in dock on left: Statue on right and Docks with inset of life on left.