DONG ENERGY A/S

The Siri platform is located in the Danish sector of the North Sea about 220km from the coast

A primer on

Island Biogeography

— And the common feaures of decommissioned oil rigs, windfarms, wrecks and artificial reefs

As most anglers and many divers know by first hand experience, man-made structures on the seabed, whether put there deliberately, such as an artificial reef, or by accident (e.g. a ship-wreck) can become a home to numerous species of fish and other wildlife. So, why are these structures sometimes a help to wildlife?

What matters is the physical presence of substantial objects on an otherwise featureless seabed. Granted, many man-made structures that end up on the seabed may also pollute—such as ships going under carrying large quantities of fuel or constructed with materials that may be toxic to marine life—hence, the need to thoroughly clean and strip down decommissioned vessels destined to become artificial reefs. But that side of the matter we'll leave for another discussion.

A structure on the seabed such as a shipwreck does not only provide shelter for fish and other marine life but in many cases also constitutes a physical substrate upon which sessile organisms, such as corals and seaweeds, can attach themselves. In this manner, the structure may become a habitat in its own right, and as such perhaps even an important one.

Consider the scenario where we have two comparable shipwrecks, one of which is positioned in a diverse area with plenty of

Text by Peter Symes

ecology

In terms of island biogeography, shipwrecks may constitute an island. Notice how the propeller and the rudder of this shipwreck in the Danish straits have become a substrate for soft corals such dead man's fingers (*Alcyonium digitatums*) as plumose anemone (*Metridium senile*) M. senile adheres to rocks, boulders, man-made structures, pebbles and shells. It favours places where the current is strong, where it can catch small organisms floating past. Smaller forms inhabit the lower shore where they are found under stones, beneath overhangs and in shaded places

corals or other natural structures, while the other is placed on a barren sandy or muddy seabed. In the latter case, this artificial structure may become a habitat for a range of creatures, which would not survive on the plain bottom. Such a wreck constitutes a virtual island in the middle of a barren expanse. And this is where the concept of *Island Biogeography* comes in.

The focal point of this scientific discipline is the species richness of isolated natural communities. Originally, this field of research was developed to study the biodiversity on actual islands, but the theoretical framework was soon extended to the concept of islands in a more generalised sense—such as an oasis in the middle of a desert, patches of bogs in the middle of farm land or expanses of grassland surrounded by highways or urbanisation. In other words, in terms of biogeography an "island" is any area of suitable habitat surrounded by an expanse of unsuitable habitat—a definition that also clearly fits a shipwreck laying in sandy area. Henceforth and within the scope of this article, the term, *island,* will refer to this wider theoretical concept rather than only actual islands.

Connectivity and pathways

In addition to their significance as habitats for residing species, islands may also play an important role in facilitating migration by providing the proverbial pit-stop or stepping stones for creatures on the move. These could either be dedicated migratory species where the individuals move due to their own locomotio—e.g trekking birds—or sessile species that propagate through dispersion of egg, larvae, pollen, seed, etc. Where islands are placed close enough together they may constitute what is termed a habitat corridor, which is a pathway or network along which species can migrate across expanses that would be otherwise impossible or prohibitively difficult to cross. Such immigration is obviously largely dependent on the distance of an island from the source of colonising creatures. Islands that are more isolated are less likely to receive immigrants than islands that are less isolated, and thus also likely to habour less species. This is known as the *distance effect.*

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Number of species

How many species can live on an island? This depends on a number of factors related to both isolation and island size. Among other things, it hinges on the relative balance between immigration and extinction. All other factors being equal larger islands tend to maintain a higher number of species and individuals. Species may actively target larger islands for their greater number of resources and available niches and larger islands may accumulate more species by chance merely by virtue of being larger. Larger habitat size also reduces the probability of extinction due to chance events.

Smaller islands, on the other hand, are more susceptible to fluctuations and disturbances in their environment. For example, epidemic diseases may easier wipe out an entire population on a small island. Populations on less isolated islands are less likely to go extinct because individuals from the source population

At Horns Rev, the Danish Energy company Elsam (now DONG Energy) built the first offshore wind farm in the North Sea. A total of 80 Vestas V80-2.0 MW units, capable of producing 160 MW, were installed

and other islands can immigrate and replenish the island population before it becomes locally extinct. This is known as the *rescue effect.*

The literature in species-area relationship is not unanimous but most plots of this relationship clearly demonstrates an equilibrial mechanism that regulates the number of species present on islands.

Recolonisation and species composition

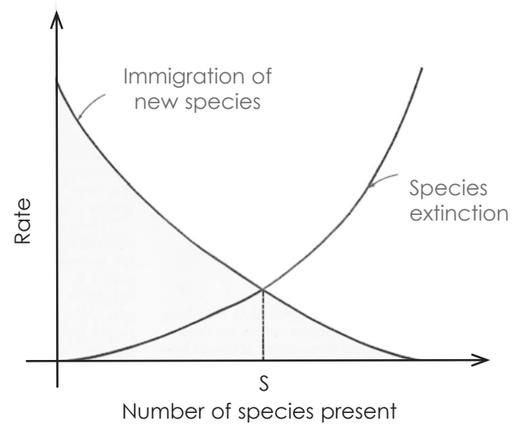
In stable communities, population numbers of component species are generally in rough balance, maintained by density-dependent feedback effects as illustrated by the curves (right), but what happens if this equilibrium is perturbed? Does the system just bounce back to where it was? In a now classic study, the insect fauna on a small mangrove island in the Florida Keys was censused. All animal life was removed by putting a cover over the islet and pumping in some toxic substance which killed off all the animal life while leaving plants unharmed. Thereafter, the islands were observed to see how fast they were re-colonised. Once a steady state was achieved, the island had roughly the same number of species present as before they were poisoned. Interestingly, the composition of species was different. Evidently, conditions on the island did not specify which particular species shall live there but determined roughly the number of species that could live there.

Continued censuring also demonstrated that while the number of species living on the island remained the same, the composition changed continually as new species arrived and old ones became locally extinct. As

"Horns Rev is situated in an extremely tough environment with strong wave action, which means, for example, that seaweed forests, together with the small fish that live in them, cannot establish themselves. We would therefore expect the positive reef effects to be even greater still in a park located for example in the more sheltered Kattegat."

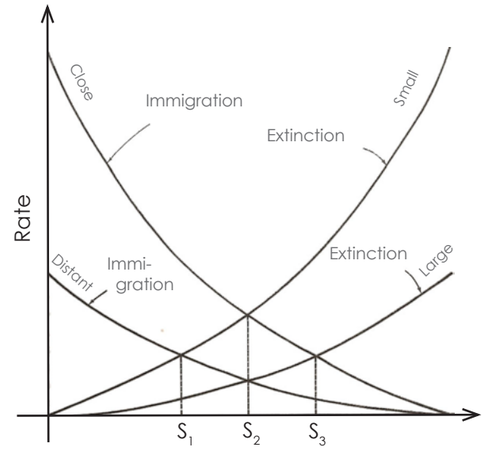
—Claus Stenberg, Biologist

The equilibrium theory of diversity on islands. The immigration rate declines as more species reach the island from a mainland source because fewer migrants will belong to new species. But extinction rate rises as immigration rate declines because as the island becomes more crowded with species, intensity of competition increases and less ecological space remains for new species. The *equilibrium number* (S) lies at the crossing of the curves.



REPRODUCES FROM "A VIEW OF LIFE", BY LURIA, GOULD AND SINGER, 1981

Predictable change of equilibrium number of species with changing size of island and distance to continental source of immigrants. Immigration rates will be higher on close islands, thus raising the immigration curve and pushing equilibrium number to the right (S_3). Equilibrium number will also rise on large islands, but for different reason: the extinction curve is lowered because the island can hold more species. Immigration rates are low to distant islands. The immigration curve is thus depressed and the equilibrium shift to the left (S_1). Equilibrium value also falls for small islands because space is more limited and extinction rates are higher.



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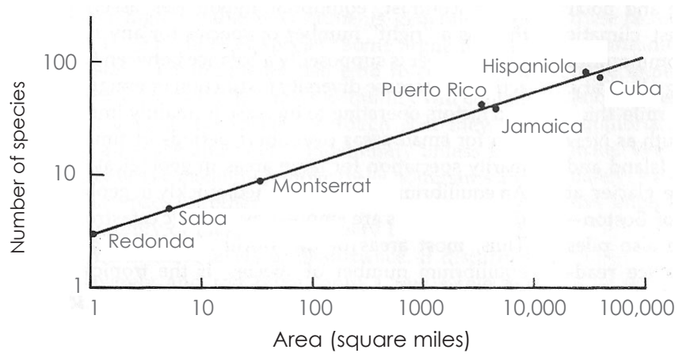
Number of species of reptiles and amphibians plotted against island area on logarithmic scales for West Indian islands. The close fit to the straight line with a slope of about 0.25 means that numbers of species increases about one-fourth as fast as island area. Equilibrial theories of diversity predict that number of species should increase in regular way with island area, other things being equal.



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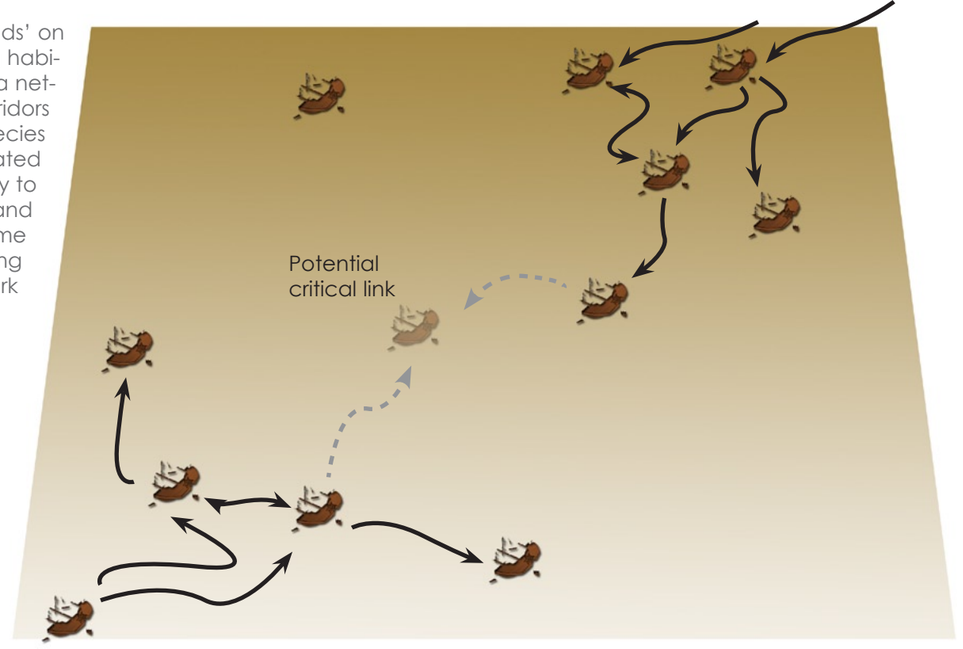


Shipwrecks as 'islands' on the seabed, providing habitat and constituting a network of habitat corridors through which species can propagate. Isolated islands are less likely to receive immigrants and few islands may become critical links in tying together a network

the equilibrium was approached, new species had increasing difficulty to gain foothold as successful colonists usurped space and resources, preventing others from settling in. At equilibrium, no new species could be added unless old ones disappeared.

Artificial reefs are not a replacement for natural ones

Recent studies of various shipwrecks in the United Kingdom and the Red Sea have shown that these artificial reefs often create new and different types of habitat than natural reefs. In 2004 the former Royal Navy frigate *HMS Scylla* was scuttled off the coast of Cornwall, UK, to become an artificial reef. From the beginning, the wreck was closely monitored by scientists observing how the marine life interacted with it.

According to Dr Keith Hiscock, an associate fellow at the Marine Biological Association in Plymouth, who carried out the majority of the colonisation research, the researchers were in for a few surprises. The first two years saw a massive colonisation of sea urchins—a species which are normally found under boulders close to shore. Then wrasse arrived and ate the sea urchins. A coral on a nearby natural reef only 30 meters from the wreck took three years, but once established on the wreck, they spread prodigiously and unexpectedly quickly.

Pink seafans on the wreck were also growing surprisingly fast, Hiscock told BBC News. They were thought to grow about one centimetre a year, but some had grown 40cm in just a few years, he explained.

Scylla Reef was created when the former Royal Navy frigate *HMS Scylla* was placed on the seabed in Whitsand Bay, southeast Cornwall, after a series of controlled explosions, on 27 March 2004. Since placement, the reef has established itself as a centre for scientific research, a habitat increasingly rich in marine life and a unique destination for recreational divers

Windmill parks

About ten years ago, the first large scale offshore wind farm in the world with 80 turbines was erected on Horns Rev (also known as Horns Reef), which is a shallow area in the eastern North Sea, about 15km (10 miles) off the westernmost point of Denmark.

In this area, which is mostly less than 20 meters deep, the number of fish species has increased since the erection of the windmill park, according to a study published in 2012 by DTU Aqua, the Danish National Institute of Aquatic Resources. The turbines at Horns Rev rest on foundations that are driven deep into the seabed and are protected by a rim of surrounding boulders, which prevent currents from eroding the base. The study suggests that these stone structures also act as artificial reefs, providing enhanced conditions for fish, with an abundant supply of food and shelter from the current, and attract fish like a rocky sea bottom.

> *"Scylla does not emulate rock reefs. You can't say, 'Oh heck, we've put so many scallop dredges through the rock reefs that we've wrecked them; let's put down another frigate as a replacement.' No, it's a different sort of habitat."*
>
> —Dr Keith Hiscock, Marine Biological Association in Plymouth

As such, the turbines have created habitats for a number of new species in the area. "Species such as the goldsinny-wrasse, eelpout and lumpfish, which like reef environments, have established themselves on the new reefs in the area—the closer we came to each turbine foundation, the more species we found," biologist Claus Stenberg stated in a DTU newsletter.

Oil rigs

When gas or oil rigs outlive their original purpose, they have to be removed. This process is called platform decommissioning and can be accomplished in four different ways: total removal, partial removal, toppling and leaving-in-place. Removing the rigs could be devastating to resident and nearby marine life and create a number of pollution problems in the process, so leaving part or all of abandoned platform structures in place has become an increasingly popular alternative.

By shearing off the top of the rig and leaving the tall steel jacket and support struts, it maintains what in many cases has already become a thriving habitat for marine life and at the same time saves oil companies money on their decommissioning obligations.

This process has become known under the popular name "Rigs-to-Reefs". It should also be noted that as oil platforms contain toxic materials and are often surrounded by contaminated debris, their complete removal is warranted in some cases. Research suggests that fish populations around the platforms are healthy, stable and

Size matters. On Rockall, a small and isolated island in the North Atlantic, small populations of sea birds seem to barely be clinging on for their dear life. Yet, it constitutes a habitat. Also beneath the surface

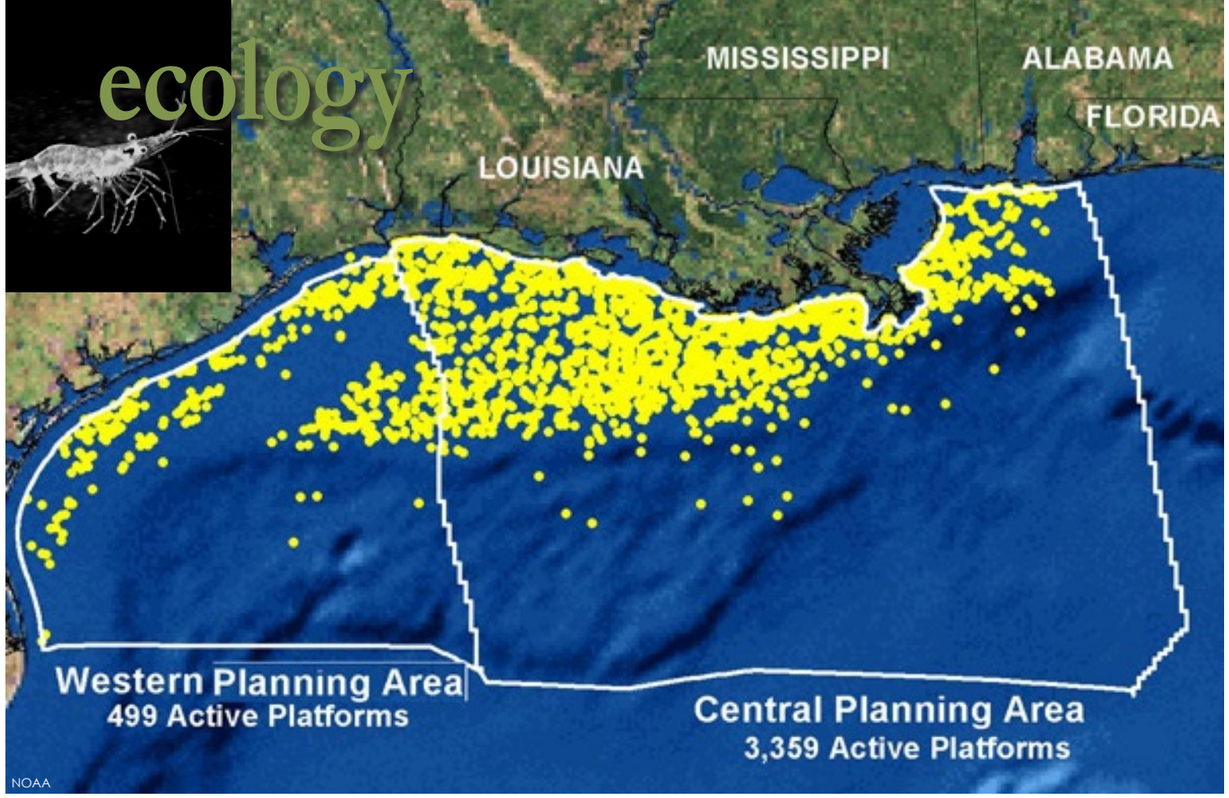


Chart of U.S. Gulf Coast platforms (above); Constructing artificial reef using concrete blocks (below)

reproducing well.

In their 2011 report, *Rigs-to-reefs: Will the deep sea benefit from artificial habitat?* authors Peter I Macreadie et al pointed out that " ... decommissioned rigs could enhance biological productivity, improve ecological connectivity, and facilitate conservation/restoration of deep-sea benthos (e.g. cold-water corals) by restricting access to fishing trawlers".

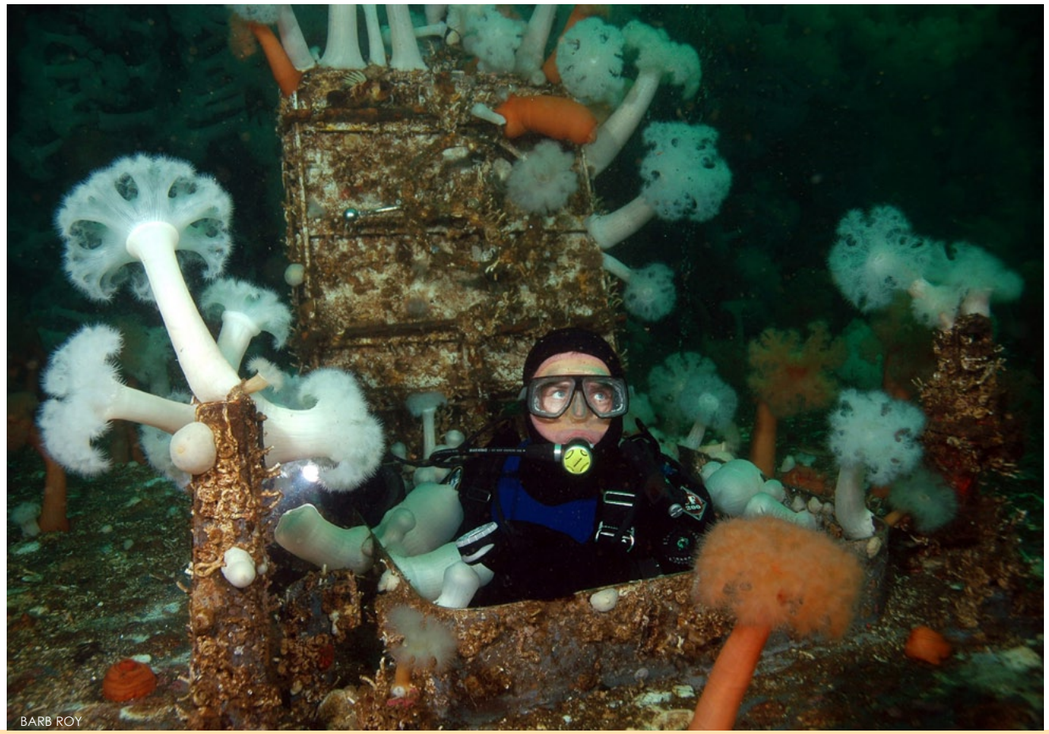
Preliminary evidence indicates that decommissioned rigs in shallower waters can also help rebuild declining fish stocks. Conversely, potential negative impacts include physical damage to existing benthic habitats within the "drop zone", undesired changes in marine food webs, facilitation of the spread of invasive species, and release of contaminants as rigs corrode.

The combined ecological and economic benefits of maintaining parts of the decommission rigs in situ has spurred many states, in particular in the United States, to legislate the matter. In Texas, the Artificial Reef Act of 1989 directed the Texas Parks and Wildlife Department to promote and enhance the artificial reef potential off Texas. To fulfill this purpose, the Department developed the Texas Artificial Reef Plan, which was adopted by the Parks and Wildlife Commission in 1990. In California, a similar law was signed into effect by the then-governor, Arnold Schwarzenegger.


U.S. DEPARTMENT OF COMMERCE

Natural islands

These theories and models also have wide applications in management of wildlife resources, including Marine Protected Areas and national parks. For these reserves to become successful, the same principles apply. Protected areas need to be both big enough to sustain diverse populations and a sufficient number of species, and to be placed where they can serve as a reservoir for migration. ■


BARB ROY

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