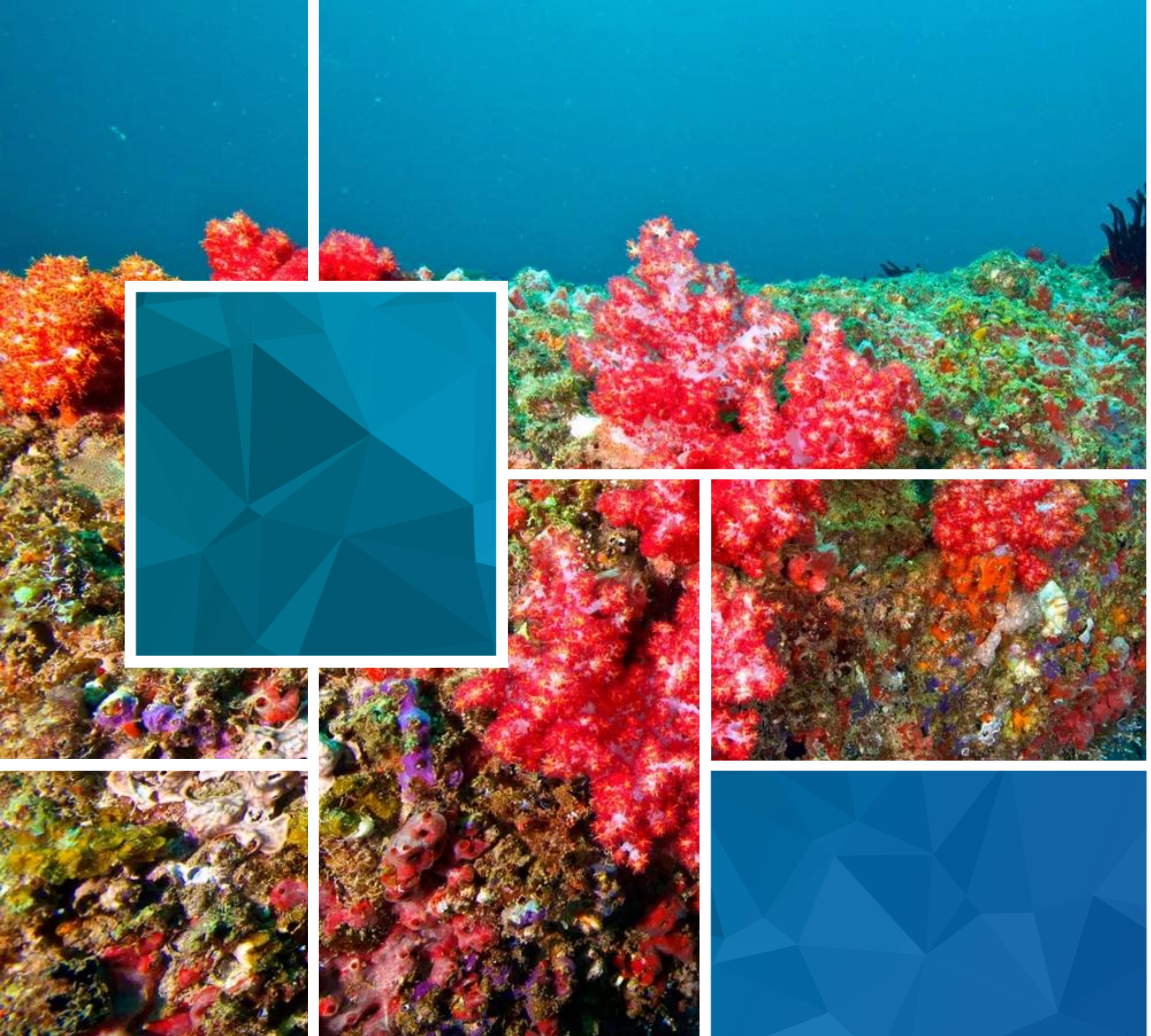

Hydrobiology

“RIGS TO REEFS”: ENHANCING BIODIVERSITY HOTSPOTS

EXPLORING THE ECOLOGICAL AND ENVIRONMENTAL BENEFITS

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Perth, 6 September 2024

INTRODUCTION TO RIGS TO REEFS

Definition of "Rigs to Reefs" with an expansion to pipelines

Concept: The idea of converting decommissioned oil & gas platforms and pipelines into artificial reefs, what are the ecological, environmental and economic benefits?

Importance: Significance in terms of ecological and economic benefits.

GLOBAL OVERVIEW OF RIGS TO REEFS

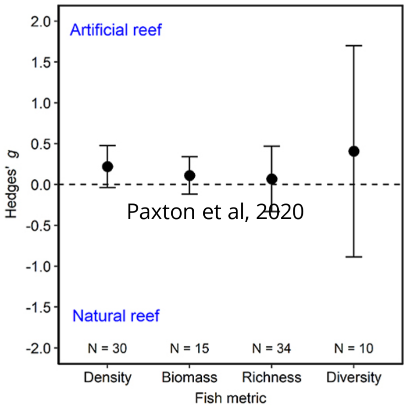
Region	Countries Involved	Number of Platforms Converted	Key Statistics	References
Gulf of Mexico	USA (Texas, Louisiana, Mississippi)	560+ (since the 1980s)	The Gulf has the largest Rigs to Reefs program globally. Texas alone has converted more than 140 platforms.	NOAA (National Oceanic and Atmospheric Administration)
North Sea	UK, Netherlands, Norway	~30 platforms	Strict environmental regulations in place; UK allows rigs to be partially decommissioned and used for reefs.	Decom North Sea, PLOS One study on rigs in European waters(
Asia-Pacific	Malaysia, Brunei, Thailand, Indonesia	~10 platforms	Southeast Asia is starting to explore Rigs to Reefs, with Malaysia leading projects in the region.	ASEAN Centre for Biodiversity, Asia-Pacific Economic Cooperation (APEC)
Australia	Australia	5 platforms (since 2020)	Australia has launched pilot projects, with DEMIRS allowing some parts of decommissioned platforms to remain as reefs.	DEMIRS, Australian Institute of Marine Science (AIMS)
West Africa	Angola, Nigeria	~10 platforms	Platforms in the Gulf of Guinea are under consideration for reef conversion, mainly driven by oil companies.	World Bank, African Development Bank studies on decommissioning(
California (Pacific)	USA (California)	~7 platforms converted	California's platforms are more heavily regulated, with emphasis on environmental and fisheries benefits.	California Ocean Science Trust

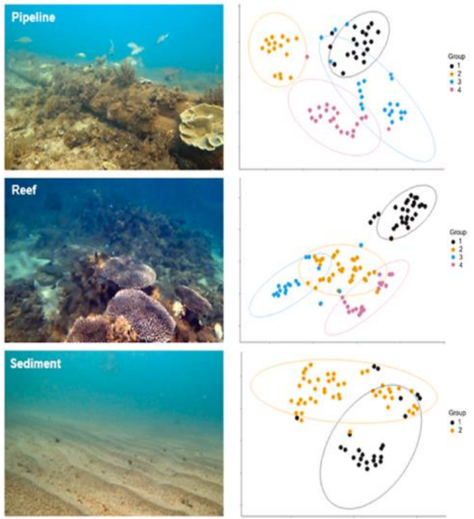
ECOLOGICAL BENEFITS OF RIGS TO REEFS

Biodiversity Hotspots & Fish Attraction

Mechanism	Explanation	Example
Habitat Creation	Artificial reefs provide hard substrate for colonization by corals, algae, sponges, and invertebrates.	Decommissioned oil platforms serve as artificial reefs in the Gulf of Mexico, attracting a variety of marine life.
Fish Aggregation	They create sheltered environments, attracting large numbers of fish, including juveniles and commercially important species.	Red Snapper and Amberjack commonly aggregate around reefed structures
Enhanced Food Availability	Colonisation by algae and filter feeders increases food supply, which supports diverse trophic levels.	Artificial reefs support food chains by attracting herbivores and carnivores(
Shelter from Predators	Structural complexity offers protection, increasing survival rates of smaller fish and invertebrates.	Artificial reefs provide refuge, reducing predation on species like juvenile groupers.
Supporting Endangered Species	Artificial reefs can provide critical habitat for endangered or rare species in areas with limited natural reefs.	Species such as Goliath Grouper have been found in artificial reef areas.
Promoting Coral Growth	Reefs offer substrate for coral colonization, supporting a coral ecosystem and associated species.	In (sub-)tropical areas, artificial reefs support coral species, promoting biodiversity

ECOLOGICAL BENEFITS

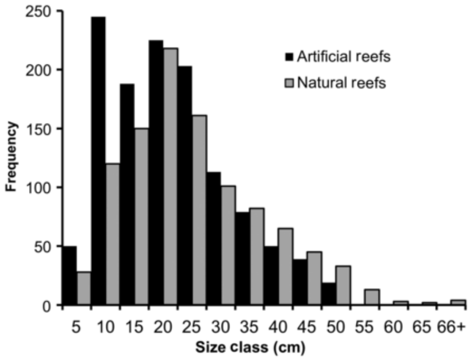




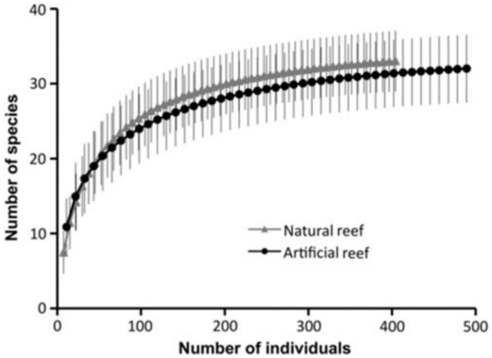
Pipeline and reef habitats had defined functional groupings where species were separated within the groups, suggesting the presence and development of a range of conditions necessary for the persistence of species and specific ecological roles.

Sediment habitat had fewer groups that were considerably spread and overlapped across both dimensions, likely due to the lack of specific physical and environmental conditions, where species identified were more likely "passing by" than fulfilling a particular ecological niche.

(Madgett et al 2023)



(Granneman and Steele 2015)



(Granneman and Steele 2015)

Madgett, A. S., Elsdon, T. S., Marnane, M. J., Schramm, K. D., & Harvey, E. S. (2023). The functional diversity of fish assemblages in the vicinity of oil and gas pipelines compared to nearby natural reef and soft sediment habitats. Marine Environmental Research, 187.

Granneman, J. E., & Steele, M. A. (2015). Effects of reef attributes on fish assemblage similarity between artificial and natural reefs. ICES Journal of Marine Science, 72(8), 2385–2397.

Paxton, A. B., Shertzer, K. W., Bacheler, N. M., Kellison, G. T., Riley, K. L., & Taylor, J. C. (2020). Meta-analysis reveals artificial reefs can be effective tools for fish community enhancement but are not one-size-fits-all. In Frontiers in Marine Science (Vol. 7).

CASE STUDY: GULF OF MEXICO

- **Species Richness:** Studies on **platforms** that have been converted into reefs show species richness between **50-70 species per site**, particularly among economically important fish species like Red Snapper (*Lutjanus campechanus*). Comparatively, fully **removed platforms or soft-bottom environments** show significantly lower richness, averaging around **30 species** in these locations.

- **Biomass:** Biomass data suggests that artificial reefs host greater fish populations, with biomass levels reaching up to **8,000 kg** per platform for reefed structures, compared to **3,000 kg** in natural or fully removed sites. This elevated biomass is attributed to the structural complexity provided by the artificial reefs, which creates an ideal habitat for juvenile fish and invertebrates, especially near deeper waters.

- **Ecosystem Services:** Artificial reefs not only enhance biodiversity but also contribute to commercial fisheries by providing a sustainable habitat for species that are harvested for economic purposes, such as groupers and snappers.

- Schulze, A., Erdner, D. L., Grimes, C. J., Holstein, D. M., & Miglietta, M. P. (2020). "Artificial Reefs in the Northern Gulf of Mexico: Community Ecology Amid the 'Ocean Sprawl.'" Frontiers in Marine Science(Frontiers).PLOS ONE:

- Wilson, C. A., et al. (2013). "Rigs and Reefs: A Comparison of the Fish Communities at Two Artificial Reefs, a Production Platform, and a Natural Reef in the Northern Gulf of Mexico."

- Minerals Management Service (2003). "Rigs to Reefs: A Case Study of the Gulf of Mexico." UNT Digital Library(UNT Digital Library).

ENVIRONMENTAL AND ECONOMIC BENEFITS

Aspect	Full Removal	Conversion to Artificial Reefs	References
Cost	$500 million or more	$200 - $300 million	OSPAR Commission(OSPAR Commission)
Economic Benefits	None	$150 million from fisheries, recreation	Gulf of Mexico Rigs-to-Reefs Program OSPAR Commission
Environmental Impact	Restores seabed to original condition	Promotes marine biodiversity, creates habitats	OSPAR Decommissioning Guidelines(OSPAR Commission
Logistical Complexity	High – complete dismantling, transport	Moderate – partial removal	UK Decommissioning Reports(Accueil)(Gov UK)
Long-Term Environmental Benefit	Neutral	Enhances marine ecosystems, carbon sequestration	Rigs-to-Reefs Ecological Studies(SpringerLink)
Regulatory Requirements	Mandated by regulators	Requires permission for partial decommissioning	NOPSEMA/ OSPAR

Cost savings

Economical studies related to Rigs to Reefs programs.

CHALLENGES AND CONCERNS

Environmental Risks:

IMS: Artificial reefs can serve as stepping stones for invasive species, allowing them to colonise new areas that were previously inaccessible.

Pollution: Some artificial reefs are made from materials that may not be environmentally safe, such as certain plastics or materials that can release toxic substances over time (this will be addressed later)

Habitat fragmentation: In some cases, the introduction of artificial structures can lead to **habitat fragmentation**. These structures may prevent the natural movement of species across the seafloor, especially for species that require large, unbroken habitats, such as certain types of fish or migratory species

Regulatory Hurdles: Legal and regulatory challenges.

CHALLENGES AND CONCERNS

Summarizing the pros and cons.

Aspect	Full Removal	Leave in Situ (Rigs-to-Reefs)
Cost	High - $500 million or more due to complete dismantling	Lower - $200 to $300 million for partial removal or toppling
Environmental Impact	Restores the seabed to natural conditions	Enhances marine habitats, supporting biodiversity and fisheries
Logistical Complexity	High - Requires complex operations for dismantling, transport, and disposal	Lower - Requires only partial removal or toppling
Legal/Regulatory	Complies with regulations requiring full decommissioning	Requires special permission for partial removal
Biodiversity Impact	Neutral - Removes artificial habitat, may harm local species dependent on structure	Positive - Increases biodiversity by providing habitat for marine species
Fisheries	No long-term benefit to fisheries	Provides long-term benefits to commercial and recreational fisheries
Carbon Footprint	Higher - Involves significant fuel consumption and emissions	Lower - Fewer operational emissions compared to full removal and carbon capture
Long-term Management	No ongoing maintenance required	May require monitoring to ensure environmental stability
Public Perception	Often seen as the most environmentally responsible option	Seen as a beneficial reuse but raises concerns about potential long-term risks
Economic Benefits	None	Generates economic benefits from tourism, diving, and fishing

RIGS TO REEFS AND CLIMATE CHANGE

- **Climate Mitigation:** In tropical and temperate waters, artificial reefs can facilitate the growth of corals and other reef-building organisms that utilise dissolved inorganic carbon to form calcium carbonate structures. As these reef-building species grow, they increase the rate at which carbonate materials are deposited, contributing to long-term carbon sequestration in the ocean floor.

- **Climate Resilience**: Potential for reefs to help ecosystems adapt to climate change.

Study Location	Key Findings	Carbon Capture Estimate	References
RGV Reef, Texas	Artificial reef structure, including sponges and soft corals, captures significant carbon, trapping it in biomass and sediment.	Not yet quantified (study ongoing)	Kline et al. (2023), University of Texas Rio Grande Valley, Friends of RGV Reef
Seagrass Meadows (Global)	Artificial reefs in seagrass meadows enhance seagrass growth by attracting fish that provide nutrients, boosting carbon sequestration.	High sequestration in meadows	Mona Andskog et al. (2023), Ph.D. study on artificial reefs in seagrass Global Seafood Alliance
Bali, Indonesia	Artificial reefs promote nutrient cycling and storage of organic carbon in sediments, functioning similarly to natural reefs in some cases.	Organic carbon stored in sediments	Brandl et al. (2021), Marine Biology study on nutrient dynamics on artificial and natural reefs

FUTURE PERSPECTIVES AND RESEARCH NEEDS

Long-Term Carbon Sequestration

- How long carbon remains sequestered in artificial reef ecosystems and whether it remains stable over time
- The potential release of carbon from degrading materials used in artificial reefs, particularly in the event of physical disturbances like storms

Comparative Studies with Natural Reefs

- How artificial reefs' carbon sequestration rates compare to natural coral reefs in the same environments.
- The ecological function of artificial reefs compared to natural reefs, particularly with respect to biodiversity and nutrient cycling

Socio-Economic Benefits

- Quantify the economic benefits for local communities from fisheries and tourism
- Evaluate the trade-offs between environmental and socio-economic goals, such as whether increased fishing pressure on artificial reefs could diminish their conservation or carbon storage potential

Material Impact

- Potential environmental risks posed by using certain materials (e.g., toxic compounds, degradation)

CONCLUSION

Ecological Benefits:

1. Increased Biodiversity: Artificial reefs provide habitat for a wide range of marine species, increasing local biodiversity. The structural complexity supports various life stages, from juvenile fish to adult predators

2. Fish Aggregation and Biomass: Artificial reefs attract and aggregate fish, often leading to higher fish biomass compared to most natural habitats. This includes commercially important species

3. Coral and other Invertebrate Habitat: Materials can support the growth of corals, sponges, ascidians and algae, creating mini ecosystems that mimic natural reefs

Economic Benefits:

1. Boost to Fisheries: By aggregating fish species, artificial reefs can enhance local fisheries, increasing catch rates for commercial and recreational fishing. This can lead to long-term economic gains for coastal communities

2. Tourism and Recreation: Artificial reefs attract divers and tourists, providing revenue from recreational activities like diving and fishing. Locations like the Gulf of Mexico have seen increased tourism thanks to artificial reefs

3. Cost-effective Decommissioning: In some cases, converting decommissioned oil platforms/ pipelines into artificial reefs is more cost-effective than full removal, saving millions in operational costs

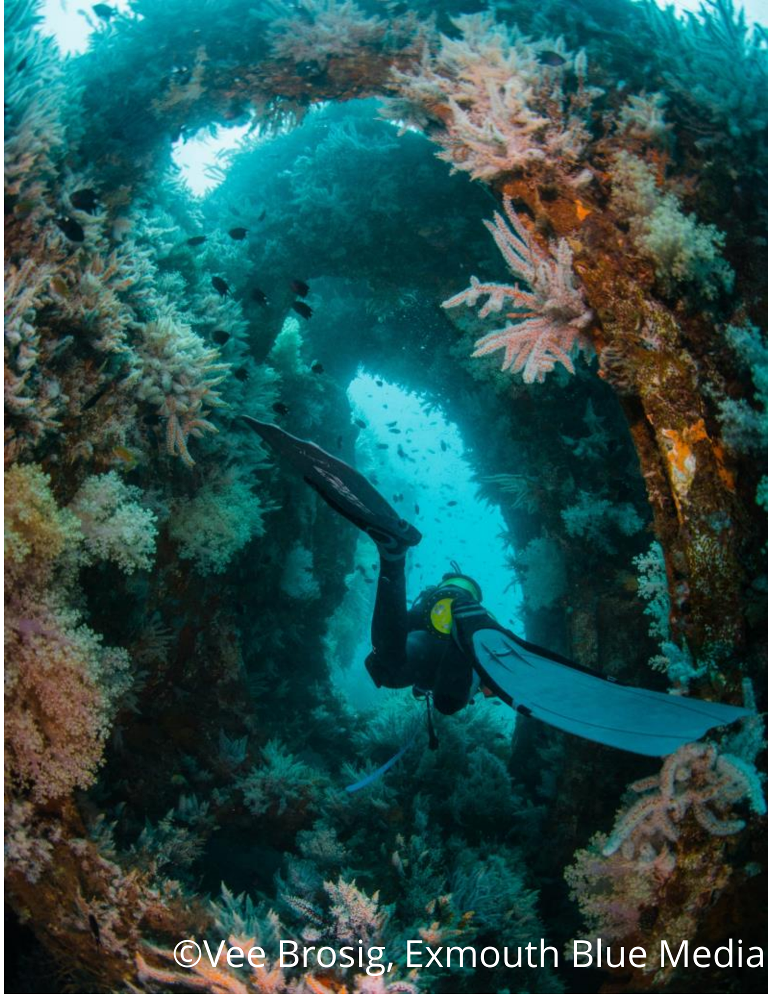
Environmental Benefits:

1. Habitat Restoration: Artificial reefs can help restore marine habitats, particularly in areas where natural reefs are degraded or absent. They can provide refuge and feeding grounds for species, helping to stabilize ecosystems, provide connectivity

2. Carbon Sequestration: By supporting coral and algal growth, artificial reefs can contribute to carbon sequestration, playing a small but important role in mitigating climate change

3. Reduction in Waste: Using decommissioned structures like oil platforms for reefs reduces the environmental footprint of removing and disposing of these massive structures

Exmouth Gulf – King Reef

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