Using photogrammetry to monitor changes to artificial reef habitat in Destin – Fort Walton Beach, Florida

Uso de fotogrametría para monitorear cambios en el hábitat de arrecifes artificiales en Destin – Fort Walton Beach, Florida

Utilisation de la photogrammétrie pour surveiller les changements dans l'habitat des récifs artificiels à Destin - Fort Walton Beach, Florida

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EXTENDED ABSTRACT

For centuries, humans have increased fishing potential by using artificial reefs (ARs) to provide suitable habitat for species of interest. Other uses include providing opportunities for recreational diving as well as enhancing shoreline and infrastructure stabilization. AR creation for habitat and recreation purposes in United States waters has realized many changes since early programs began. Some of the most impactful of these changes include the elimination of harmful (e.g. tires, white goods and plastics) or ill-suited materials such as thin metals that do not last long (e.g. car bodies and storage boxes). Today's programs also work to avoid negative interactions with habitats of interest (e.g. corals and seagrass beds) while also deploying materials that are favorable to specific species or life stages for targeted conservation and recreational benefit.

In recent decades, AR management has sought to create balance among multiple goals, including: 1) creating essential habitat for commercially and recreationally important species, 2) increasing ecotourism opportunities through the creation of dive sites, 3) maximizing AR longevity and durability given the potential negative effects of large disturbances such as tropical cyclones, and 4) understanding how ARs influence the benthic landscape. AR research, as it relates to marine species attraction, production and overall ecosystem services, has been extensive (Pickering and Whitmarsh 1997). Many of the studies discussed in Pickering and Whitmarsh 1997 generally rely on in-situ sampling methodologies including biological sampling as well as invasive and non- invasive surveys for determining presence, abundance and use. Describing changes to marine habitat has mostly relied on notated, repeated observations and point measurements over time and only recently began to incorporate remote sensing technologies to monitor habitat changes. While primitive modeling tools have been developed to determine AR stability and durability, there are numerous factors not generally considered in these simplified models that may misinform AR construction as it relates to site longevity. Although qualitative observations of AR longevity and stability over the last half century have resulted in additional contributions to AR management, there is a lack of entire AR site assessment information as well as temporal monitoring data and methodologies. Technological advancements have helped make low-cost assessment tools more readily available, and there is an opportunity to leverage these new tools to better assess AR habitat.

Large-vessel (length: >18m) ARs have been shown to support a variety of species of marine fish, while the value of these ARs to recreational diving and fishing is evident. Large-vessel ARs provide a centralized location for divers to experience a dive profile that maximizes bottom time and renders disorientation less likely. Moreover, studies have shown that these large vessels are prioritized by divers and fishers over nearby natural reefs, thus reducing negative impacts to the natural systems due to anchor strikes and negative diver interaction (Leeworthy et al. 2006).

While thousands of ARs have been deployed throughout Florida, this study will focus on the last three years when vessel deployments increased in the Northern Gulf of Mexico region, specifically offshore Destin-Fort Walton Beach, FL. Since September 2020, a total of 18 large (>18m) vessels were intentionally deployed as ARs throughout the state of Florida. Thirteen of these vessels (mean length: 33.14±4.29m, Table 1) have been deployed (two TBD) offshore (mean depth: 32.9±1.5) Destin–Fort Walton Beach, FL (Figure 1). Monitoring changes to these sites is a priority to better inform future AR management. In the last five years, photogrammetry (the creation of 3D-models from photographs) has been used to monitor coral growth on natural reefs (Cahyono et al. 2020) but has not been widely used to monitor ARs.

3D models have been created employing photogrammetry methodologies in collaboration with Reef Smart Guides for each of the recently deployed vessels. Photogrammetry involves the use of multiple image pairs to infer relative size and positioning of physical objects. The approach has been around in various forms since the late 1800s but has recently become more accessible with the advent of increasingly powerful personal computing power and the development of more robust algorithms and software that are available to regular consumers. Data for these 3D models were processed through two off-the-shelf programs, namely Agisoft Metashape and Blender.

Table 1. Large vessels (>18m) deployed and planned for deployment offshore Destin-Fort Walton Beach since September 2020 including status of photogrammetry data collection.

Vessel Name	Vessel Length (m)	Deployment Depth (m)	Deployment Date	Photogrammetry Data Collection Date
S/V DYLAN	18.6	36.3	September 10, 2020	August 23, 2022
USAF BIG DAWG	28.3	31.7	May 7, 2021	August 24, 2022
M/V BRANNON	19.8	36.3	July 29, 2021	August 23, 2022
M/V MISS JOANN	19.5	36.3	March 2, 2022	August 23, 2022
M/V COURAGEOUS	57.6	39.6	April 28, 2022	May 8, 2022
M/V MISS NELLIE	19.1	35.4	August 23, 2022	August 23, 2022
S/V CORDONAZO	20.4	34.4	September 7, 2022	To be mapped
R/V MANTA	54.9	33.8	January 15, 2023	October 6, 2023
R/V DOLPHIN	58.5	37.2	March 15, 2023	June 23, 2023
RMS CYCLOPS	32.0	21.9	April 18, 2023	To be mapped
RMS ATLANTIS	38.1	24.4	June 29, 2023	July 16, 2023
M/V CRIMSON WHITE	41.1	25.6	To be deployed	To be mapped
S/V AJ FLYING EAGLE	22.9	34.4	To be deployed	To be mapped
Mean±SE	33.1±4.3	32.9±1.5		

Divers conducted data collection dives using two GoPro cameras (version 7 or above) mounted on aluminum poles with a spacing of approximately 0.75 to 1m. A 15,000-lumen flood light was mounted to the pole between the dual cameras to ensure adequate lighting for data capture and to avoid backscatter from marine particulates. Divers began at a termination point on the vessel, 5 to 10m away (depending on visibility) from the structure and maintained that distance while swimming at 1m/s in successive passes around the structure. The general dive profile required starting the dive where the structure meets the seabed and gradually ascending from there.

Subsequent passes around the structure were spaced at increasingly shallower depths in such a way as to guarantee an overlap in the field of view of the cameras of 50% or more with previous passes (Figure 2a). Divers concluded the data collection with a final series of passes with cameras oriented down, aimed at the top surface of the structure.

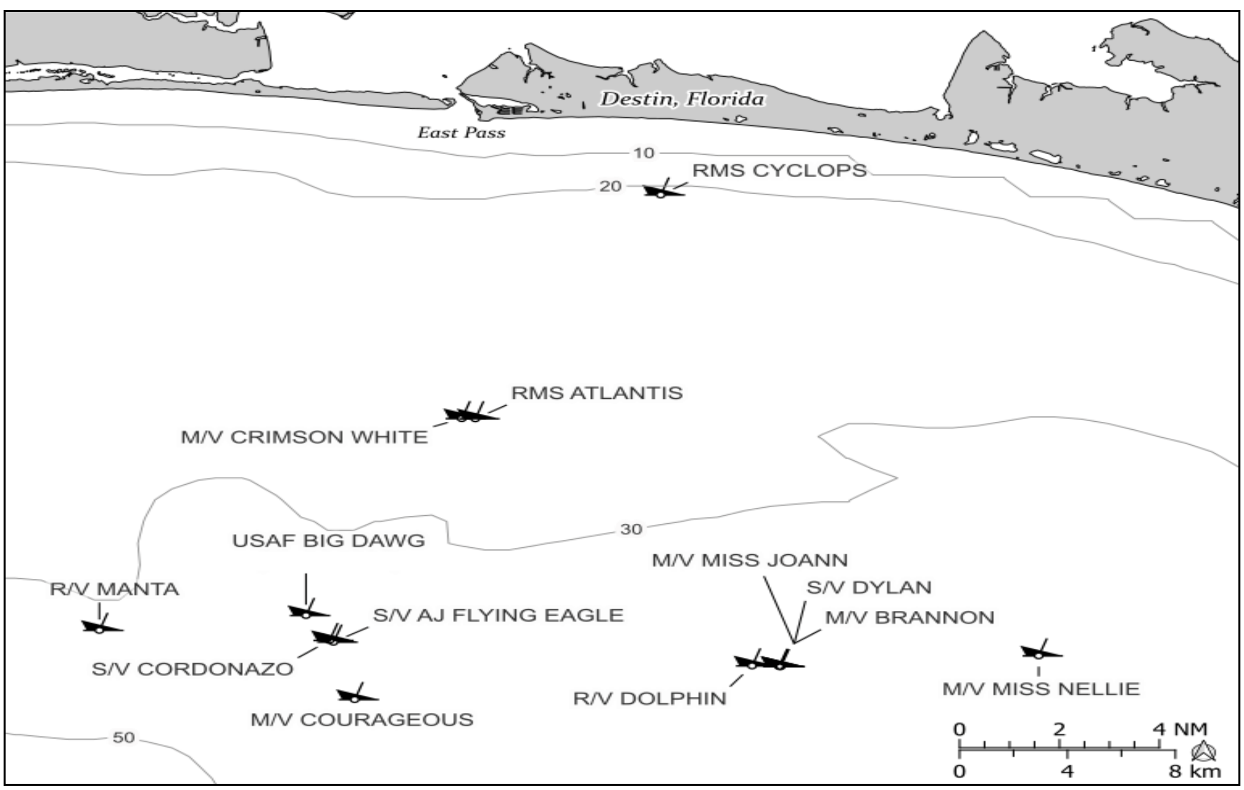

Figure 1. Map of large-vessel (>18m) artificial reefs deployed offshore Destin-Fort Walton Beach, Florida since September 2020. Photogrammetry methods have been used for these vessels to create 3D models for monitoring and to enhance user experience..

A)

B)

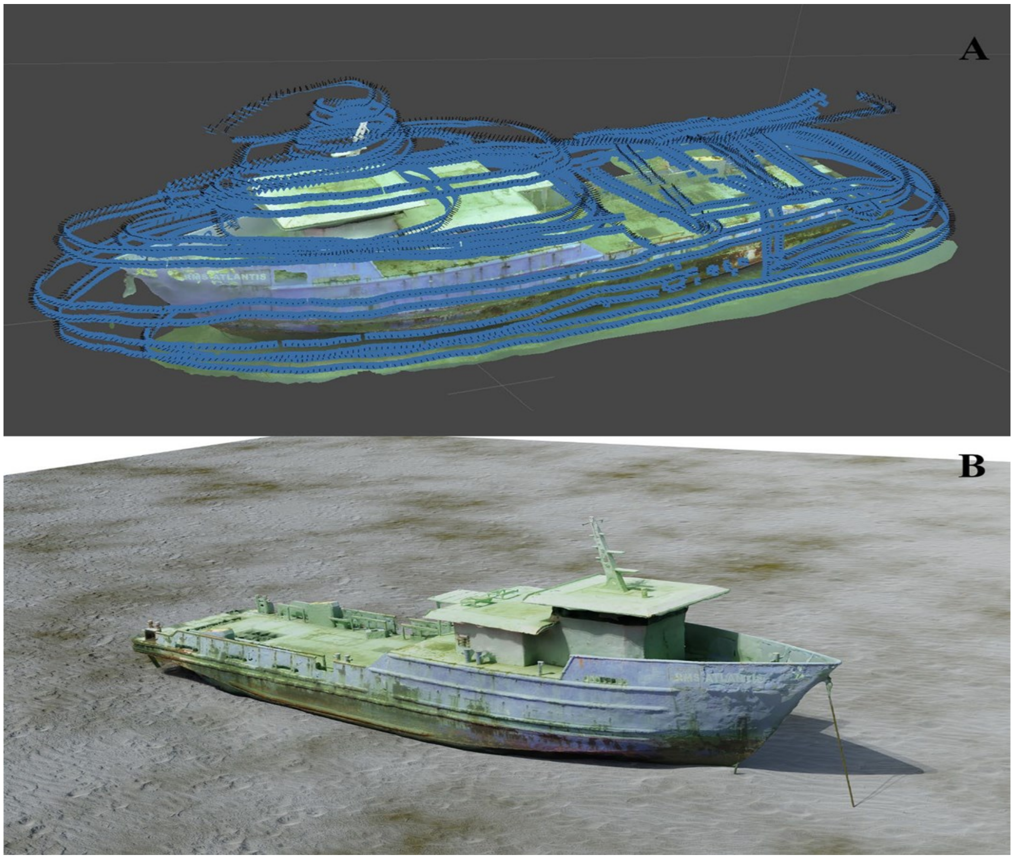

Figure 2. A) A textured mesh featuring estimated camera positions that outline the path taken by a swimming diver as they collected data on the artificial reef. Camera positions are calculated based on the alignment algorithms in Agisoft Metashape. An overlap of at least 50% in successive images is required to ensure proper alignment and an accurate 3D model. B) The completed 3D model of the RMS ATLANTIS, a 38.1m vessel deployed in June 2023 offshore Destin-Fort Walton Beach, Florida.

The raw video footage was then processed into individual frames taken at varying intervals to ensure sufficient overlap in the image from one frame to the next. These frames were processed through the photogrammetry software to produce a 3D model of the structure (Figure 2b). Interactive models can be viewed at https://www.destinfwb.com/explore/eco-tourism/artificial-reefs/.

These vessel sites will be remodeled every five years or following a large tropical weather event. The monitoring schedule will allow for a suitable interval to observe changes in the ARs as they mature. While the accuracy of these models is not accurate enough to determine finite changes such as encrusting organism growth rate, total encrusting organism coverage over the reef can be determined following methods outlined in Vincent et al. 2021. This method of AR monitoring will enable quantitative inferences and provide important data that can be used to inform future AR initiatives.

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KEYWORDS: Protected areas, coastal ecosystems, Environmental Impact Assessment, fisheries management, habitat threats

LITERATURE CITED

Cahyono, A.B., A.C. Wibisono, D. Saptarini, R.I. Permadi, Y. Budisusanto, and H. Hidaya. 2020. Underwater photogrammetry application for coral reef mapping and monitoring. International Journal on Advanced Science Engineering and Information Technology. 10:293-297.

Fukunaga, A., Burns, J.H., Craig, B.K. and Kosaki, R.K., 2019. Integrating three-dimensional benthic habitat characterization techniques into ecological monitoring of coral reefs. Journal of Marine Science and Engineering. 7(2):1-27.

Leeworthy, V.R., T. Maher, and E.A. Stone. 2006. Can artificial reefs alter user pressure on adjacent natural reefs? Bulletin of Marine Science, 78(1):29-38.

Pickering, H., and D. Whitmarsh. 1997. Artificial reefs and fisheries exploitation: a review of the 'attraction versus production' debate, the influence of design and its significance for policy. Fisheries Research. 31(1-2):39- 59.

Vincent, M., U.B. Isabel, F. Louis, P. Romain, G. Rémi and D. Kenneth. 2021, August. Underwater Photogrammetry as an Environmental Assessment Tool to Monitor Coral Reefs and Artificial Structures. In Offshore Technology Conference (p. D021S027R003). OTC.