Attraction or Production of Fishes by Artificial Reefs in Maryland
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Given recent developments in Maryland's Atlantic Ocean management interest (Mid-Atlantic Regional Council on the Ocean – MARCO – and offshore wind), this paper discusses how artificial reefs could be considered as part of a larger marine spatial plan. This is specifically referencing Recommendation #3 – "Development of a Benthologic Master Plan" or a marine spatial plan that considers the location of both artificial and natural reefs in the larger Ocean ecosystem.

In response to a request for information about the attraction vs. production debate surrounding artificial reefs, this document discusses the following: an attraction vs. production issue summary, an analysis of the issue for Maryland and a list of staff recommendations.

During the development of this document, comments were solicited from both Fisheries Service and the Chesapeake & Coastal Program. One comment to bear in mind as this document is reviewed is that the original stakeholder-based process that was undertaken to develop Maryland's Artificial Reef Management Plan primarily focused on the provision of fishing opportunities. Constituents that aided in the development of the plan provided extensive feedback on current artificial reef plans and some of the recommendations presented in this document would likely need to be vetted through a similar process before adoption.

Issue Summary for Maryland

Current artificial reef development in Maryland waters may best be described as an enhancement of angler access and opportunity than as an enhancement of fisheries resources. However, enhancement of the reef associated community, including oysters, blennies, gobys, toadfish, sea squirts, bryozoans and resultant effects on fisheries resources has not been fully evaluated and may be underestimated. Increased angling efficiency on populations concentrated on artificial reefs may offset population gains that result from increased foraging efficiency or reduced natural mortality[1].

Staff Recommendations

Based on a review of artificial reef literature and other state artificial reef management plans, as well as discussions with species experts in Maryland, there are a number of things the state, in conjunction with stakeholders, may want to pursue regarding artificial reef structures.

Recommendation #1:
Add information describing the attraction/production debate within the State's artificial reef management plan. Maryland's current artificial reef management plan does not adequately address the attraction/production issue. Reef plans from other states provide a section that covers this topic and also describe how this issue could be handled through management actions or construction of the reef structures. Inclusion of this information will give context for when and where reef development may be beneficial.

Recommendation #2:
Consider designating several sites as "no take" or "protected areas" that would provide protected habitat structure for fish that use artificial reef structures during one or more of their life stages. Maryland's plan currently acknowledges that there is lack of hard-bottom substrate that provides fish habitat in the upper Maryland's Chesapeake Bay and ocean waters off the state's coasts. The plan describes one potential reef type as a "research reef" where fishing and other similar activities would not be permitted. The plan also describes how artificial reefs could be considered as one of the tools available for fisheries management. A provision for protected artificial reefs and subsequent monitoring and research would help to ensure that the attraction/production debate was adequately addressed.

Recommendation #3:
Insert a "Benthologic Development Master Plan" section in the Artificial Reef Management Plan that delineates areas for future artificial reef development and trawling areas in coastal ocean waters. As with terrestrial site development, a detailed bathymetric map and site plans of current and future artificial reef development activity is needed. Master planning for reef development should be all inclusive so as to capture other bathymetric

development projects such as oyster bar restoration, SAV restoration, infrastructure development, and energy development. Furthermore, artificial reef development renders the sea floor and portions of water column inaccessible to other fishery activities such as trawl, dredge, drift gill net, and pots. Pre-development demarcation of fishery and development zones (envelopes) predicated upon species biology and stakeholder input is necessary to minimize stakeholder conflicts. A comprehensive benthologic development plan can be used to better leverage funds to complete projects.

Recommendation #4:
Revise the target finfish species information in the Artificial Reef Management Plan for Maryland (2007) to better reflect actual fish community composition and probability of population enhancement. Finfish communities that inhabit reef structures will vary among oligohaline/mesohaline, polyhaline, and coastal ocean (continental shelf) waters. Information regarding utilization of reef structure by life history stage should be included. Furthermore, several fish species are listed that would not be likely candidates for population enhancement or access enhancement by reef construction (yellow perch, catfish, red hake, pollock, northern kingfish).

Recommendation #5:
Explore the feasibility of developing shallow water artificial reefs that could be utilized by young-of-year and juvenile fish. Shallow water reefs having pronounced three-dimensional structure could serve as both shellfish enhancement projects and habitat enhancement for juvenile finfish.

Recommendation #6:
Develop a fully funded and statistically sound monitoring program. Pre- and post-construction monitoring is limited. Insufficient data exists to evaluate the structural and biological condition of reef projects. Components of a monitoring and research program are described in the 1994 Aquatic Reef Habitat Plan[2]. This monitoring program should be incorporated into the implementation plan of the current and future artificial reef program.

Recommendation #7:
Estimate cost efficiency of fish population enhancement by reef development versus regulatory action. Artificial reef development programs have significant associated costs for materials, transport, labor, and monitoring. Regulatory actions are comparatively low cost to implement, but may have significant impact to economies associated with the managed fish species. A cost benefit analysis would be useful to best determine which action(s) to pursue (reef development or regulatory action) to achieve the desired response in the fish population.

Issue Summary

Over the past decade, a number of states and other coastal managing bodies have developed artificial reef management plans. Many of these plans cite a lack or loss of hard-bottom substrate as a motivating factor to place artificial reef structures in offshore waters. One of the main discussions in the field of artificial reef management is the attraction vs. production debate.

The consensus of the 8th Conference on Artificial Reefs and Artificial Habitats (CARAH) (2005) was that artificial reefs "are now believed to be more of a continuum, both attracting and enhancing fish populations. Properly constructed, and strategically sited artificial reefs can enhance fish habitat, provide more access to quality fishing grounds, benefit fishermen, divers and the economies of shore communities, increase total biomass in a given area and provide managers with yet another option for conserving, managing and developing fishery resources.[3]"

In addition to its consensus on the attraction vs. production debate, the CARAH consensus was important for its identification of proper construction and strategic siting as principal factors in determining artificial reef functionality and fisheries enhancement potential. Powers et al.[1] suggest that only areas limited by available habitat are candidates for artificial reef placement. If finfish declines are related to habitat degradation[4], artificial reef siting should occur in waters where reef habitat has been degraded but remains favorable to reef associated species. The purpose for each artificial reef project must be clearly defined as the siting requirements for reefs that enhance fishing versus provide nursery habitat for species may be different.

Potential Impact of Artificial Reefs on Fish Species in Maryland

Artificial reef development in Maryland's coastal ocean and estuarine waters will likely enhance fisheries by aggregating prey or by providing refuge areas for species that utilize structure in one or more of their life stages[5]. Species that utilize reef structure for refuge and foraging opportunities should receive the greatest benefit due to reduced natural mortality and increased growth rate[6]. In some cases, artificial reef structures may enhance fish growth as a result of increased prey foraging efficiency[1] assuming that there is no cost incurred by foraging on reef-associated prey. Appendix A provides a comprehensive overview of the likelihood that artificial reefs may impact fish populations by either enhancing fish abundance through the creation of refuge areas resulting in reduced mortality or by enhancing fish biomass by providing prey and increasing growth rate.

Reef-associated fish species that may experience varying degrees of direct population gains from current artificial reef development in coastal ocean and Chesapeake Bay waters are black sea bass, scup, tautog, spot, red drum, and cunner. These six species utilize reef structure for refuge during two or more stages of their life history. Black sea bass and scup are the only two species identified in the Artificial Reef Management Plan

for Maryland[7] that utilize reef structures during their early life history. Juvenile and adult black sea bass, scup, tautog and cunner have an affinity for structural complexity and may utilize reefs for adult habitat and potentially nursery areas. Other fish populations will likely experience some limited level of population enhancement due to increased foraging efficiency and structural habitat on artificial reef structures in Maryland. However, population gains from the establishment of new refuge and forage areas may be offset by increased angling efficiency on concentrated individuals[1].

The potential for fishery enhancement from reef construction in shallow (<5 m) estuarine waters is less clear. Many estuarine-dependent species utilize different habitats during their life cycle. For example, anadromous fish in the Chesapeake Bay such as striped bass do not spawn in mainstem areas of Chesapeake Bay[8,9] and nursery habitat for the young-of-year does not occur where artificial reefs have been constructed[7]. This is also evident in the Maryland Department of Natural Resources (MD DNR) juvenile striped bass seine survey that targets shallow shoreline waters of tributaries[10].

Oyster reef restoration studies may provide insight into artificial reef utilization by juvenile and adult finfish. Oyster reef restoration can increase the abundance of reef associated macroinvertebrates and fishes[11]. By extension, artificial reefs constructed of materials such as concrete that encourage these communities might be expected to have a similar effect. Benthic invertebrates that colonize oyster reefs are prey for adult Atlantic croaker, spot, and white perch as well as for juvenile weakfish and striped bass[11]. Atlantic croaker, spot, and juvenile weakfish also forage on invertebrates and fish over open mud and silt substrates[8] suggesting that structural habitat is unlikely to be a limiting factor for those species.

Peterson et al.[4] reviewed six oyster reef restoration studies in southeastern Atlantic estuaries (including the Chesapeake Bay). Only one species identified in the Artificial Reef Management Plan for Maryland[7] – black sea bass – was documented as a having increased population density on reef structure. Black sea bass are a rather uncommon species for the recreational angler in the Maryland portion of the Chesapeake but are heavily fished on structured bottom in the Atlantic. Finfish species identified in Maryland's Artificial Reef Management Plan are less likely to use artificial reef structures for refuge than for foraging.

Young-of-year survival influences year class strength and population abundance[12,13]. Artificial reefs used to increase fish abundance should be placed in nursery areas for the target species unless a population bottleneck occurs during another life history stage. In the Chesapeake Bay, nursery reefs as described in section 5.1.2 of the Artificial Reef Management Plan[7] would mimic oyster reefs in structure and location[2], though current regulations and a host of navigation issues may preclude their placement in some shallow waters. The 20 existing artificial reefs in the Chesapeake Bay are located in deeper waters where they are promoted as, and are likely to function as, fishing reefs (section 5.1.1 of Artificial Reef Management Plan for Maryland[7]). These reefs have limited spatial overlap with nursery areas and are not expected to provide nursery habitat for target fish species.

References

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Appendix A

Likelihood of population enhancement due to utilization of reef structure for fish species identified in the Artificial Reef Management Plan for Maryland (2007). Potential for population enhancement was based on the number of life history stages using reef structures: yes (3 or more), some (1-2), no (0).

Species	Enhancement		Chesapeake Bay (CB) or coastal ocean (O)
	Abundance (provides refuge)	Biomass (provides prey)	
Black seabass[8, 14,15,16,17,18]	Yes	Yes	O, CB
Tautog[8,14,15,17]	Yes	Yes	O,CB
Cunner*[8,14,15]	Yes	Yes	O
Scup[8,14,15,17]	Yes	Yes	O
Atlantic croaker[8,14,15,16,17,19,20]	Some	Yes	O,CB
Spot[8,14,15,16,17]	Some	Yes	O,CB
Red drum[8,14,15,16,17]	Some	Yes	O,CB
King mackerel[8,14,15]	Some	Yes	O
Bluefish[8,14,15,16,17,21]	Some	Some	O,CB
Summer flounder[8,14,15,16]	Some	Some	O,CB
Weakfish[8,14,15,16,17]	Some	Some	O,CB
Spotted seatrout[8,14,15]	Some	Some	O,CB
Black drum[8,14,15,16,22]	Some	Some	O,CB
Striped bass[8,14,15,16,17]	No	Yes	O,CB
White perch	No	Some	CB
Spotted hake[8,14,15,16]	No	Some	O,CB
Catfish	No	No	CB
Yellow perch	No	No	CB
Pollock[8,14,15,16]	No	No	O
Red hake	No	No	O,CB
Northern kingfish[8,14,15]	No	No	O