L

VIRGINIA RECREATIONAL FISHING DEVELOPMENT FUND
SUMMARY PROJECT APPLICATION*

NAME AND ADDRESS OF APPLICANT:

Virginia Institute of Marine Science
P.O. Box 1346
Gloucester Point, VA 23062

PROJECT LEADER (name, phone, e-mail):

Romuald N. Lipcius
(804) 684-7330, rom@vims.edu

PRIORITY AREA OF CONCERN:

Habitat Improvement

PROJECT LOCATION:

Lynnhaven Bay, Virginia

DESCRIPTIVE TITLE OF PROJECT:

Utility of Alternative Reefs to Enhance Production of Recreational Fish and Oyster Simultaneously

PROJECT SUMMARY:

Recent studies indicate that the production of recreational fish (e.g., sheepshead, tautog), can be increased significantly with reef structures that simultaneously enhance survival and abundance of the native oyster. We aim to examine this experimentally in the Lynnhaven River system, and determine the most effective reef structure that concurrently enhances recreational fish production and oyster abundance. The field study will be conducted on the oyster leases of residents who have agreed to our use of their leases. The study is coordinated with local (City of Virginia Beach), private (Lynnhaven 2007, CBF, CCA) and governmental (VMRC, ACoE) agencies, and a complementary food web project (Seitz) to boost the project's effectiveness.

EXPECTED BENEFITS:

We expect that the study's results will serve as a model for the construction, deployment and utility of combined artificial fish and oyster reefs throughout Chesapeake Bay. The fish reefs are projected to increase production of recreational fish such as sheepshead and tautog locally, as well as enhancing the abundance of native oyster and its associated community which provides the food base for the recreational fish. The fish in turn provide a measure of protection for native oyster by preying upon oyster predators (e.g., mud crabs). The cooperation among local, private and governmental agencies will also serve as a model of co-management of the Commonwealth's resources in a manner that maximizes the resource benefits, while minimizing costs to private agencies, the Commonwealth, the federal government and private taxpayers.

COSTS:

VMRC Funding:	199,643
Recipient Funding:	40,447
Total Costs:	**240,090**

Detailed budget must be included with proposal.

Updated 6/1/05

***This form alone does not constitute a complete application, see application instructions or contact Sonya Davis at 757-247-8155 or sonya.davis@mrc.virginia.gov : Due dates are June 15 (Jul. – Nov. Cycle) and December 15 (Jan. – May Cycle)**

VMRC Recreational Fish/Oyster Reef
R.N. Lipcius, PI

		VMRC	VIMS	TOTAL
Salaries				
Lipcius, PI - 1 mon	12%	8,583	4,291	12,874
Marine Scientist1 (BS level) - 12 mon	100%	30,228		30,228
Graduate Res Assistant (1 @ 12 mon)		18,156		18,156
Fringe, 30% salaries; 7.65% waged		11,643	1,287	12,931
Supplies				
SCUBA supplies and accessories ($8,000); Reef materials ($36,000); miscellaneous field supplies ($4,500); Software ($1200)		49,700		49,700
Travel				
Meetings and Field sites - ~275 miles RT @$.58/mile VIMS truck; tolls; Lodging; Per diem		5,500		5,500
Vessel Rental				
Rental - $120/day x 24 days	24	2,880		2,880
Subcontract				
Deployment of reefs on site		14,000		14,000
Equipment - 1 underwater video system for fish production estimation @ 28,000		28,000		28,000
Facilities & Administrative Costs		30,953	34,868	65,821
Total		199,643	40,447	240,090

Personnel salaries are for the coordination and conduct of the work.

We have applied the allowable 30% fringe for faculty and 7.65% for hourly staff.

We request 24 days of boat time on a VIMS vessel (large privateer) for sampling the reefs ($2880) plus fuel (listed in supplies).

Supply costs include reef building materials, sampling materials, some SCUBA gear that will be used in this project and in future projects, software for the video system, and miscellaneous supplies.

Supplies also include vessel fuel at $50 fuel per day for 24 days. Travel includes trucks for trailering boats from the VIMS main campus to field sites on the Lynnhaven Bay at 41 miles one-way (0.58 per mile x 2 ways= $47/day) for 24 days.

In addition, we request $28,000 for a video system critical to estimate fish production, and which will be used in subsequent years with additional artificial fish reefs.

The subcontract is for a small barge to deploy the reefs at the two locations.

Indirect costs are charged at the rate of 25%. Cost share (match) to be provided by VIMS includes salary and fringe benefits for the principal investigator as well as unrecovered Facilities and Administrative Costs.

Utility of Alternative Reefs to Enhance Production of Recreational Fish and Oyster Simultaneously

P.I.: R.N. Lipcius

1.) **Need**

A comprehensive review and recent field investigations have concluded that the production of various recreationally valuable fish can be increased by different types of artificial oyster reefs (Peterson et al. 2003). Enhancement occurs either through the provision of habitat and food for structure-dependent fish such as sheepshead and tautog (recruitment enhancement), or by increasing the availability of reef prey (growth enhancement) for transient fish such as black sea bass that use the reefs as a foraging ground. For example, the biomass of sheepshead was increased annually by 0.6 kg 10 m^{-2} and that of black sea bass by 0.4 kg 10 m^{-2} (Peterson et al. 2003). Commercially valuable fish can also be enhanced by oyster reefs, as in the case in New Zealand where blue cod fishery landings increased by over 500 % in areas where oyster reefs were protected to provide habitat for blue cod (Cranfield et al. 2001). In general, the production of recreationally and commercially important fish has been augmented considerably by a diverse set of artificial fish reefs, including oyster reefs, even when such reefs also concentrate fish (Seaman 2000).

The effectiveness of alternative reef structures as excellent oyster and mussel habitat was evident in our examination of a modular reef structure in the lower Rappahannock River. In May 2005, we measured the abundance and biomass of Eastern oyster and hooked mussel on a concrete modular reef that was deployed in subtidal waters (7-9 m depth) in October 2000 (Lipcius and Burke 2006). The resulting 120 samples demonstrated that the reef had been colonized heavily by oysters and mussels, which survived at extremely high densities. There were on average 1,000 oysters and nearly 10,000 mussels per m^2 of river bottom on the reef. In addition, the habitat provided by the oysters and mussels supported a diverse assemblage of mud crabs, polychaete worms, small mollusks, reef fish, and other species that serve as potential prey for larger, recreationally valuable fish (Seitz et al. manuscript in preparation).

Our recent investigations have indicated that particular types of alternative oyster reefs (Figures 1 and 2) not only increase oyster abundance significantly (Lipcius and Burke 2006), but they apparently also enhance the abundance of recreationally valuable fish such as sheepshead, black sea bass, and tautog. Specifically, various recreational fishers have caught these species near the alternative oyster reefs, and professional divers have directly observed these fish on or near the alternative oyster reefs (David Bushey, Commonwealth Pro-Dive, personal communication). Numerous observations indicated that sheepshead, black sea bass, tautog, and other fish utilized the reef as shelter or a foraging area. These observations are consistent with the general conclusions by Peterson et al. (2003) on the efficacy of properly designed artificial reefs, including oyster reefs, in enhancing the production of recreational fish species.

We have recently begun a cooperative effort to evaluate the effectiveness of different types of artificial reefs in enhancing the abundance and production of oyster, blue crab, and fish that utilize reefs as shelter or foraging grounds. The effort involves VIMS, Army Corps of Engineers—Norfolk District, Chesapeake Bay Foundation, Rappahannock Preservation Society, Lynnhaven 2007, City of Virginia Beach and private citizens. We will also involve the Coastal Conservation Association (CCA) due to their interest in augmenting the production of recreational fish for Virginia anglers. The overall goal of this effort is to determine the optimal structure and placement of artificial reefs that will simultaneously maximize the production of fish, oyster and blue crab. Some work has been conducted in the Rappahannock River (Lipcius and Burke 2006, Burke and Lipcius manuscript in preparation, Seitz et al. manuscript in preparation) and the Lynnhaven River system (Burke et al. manuscript in preparation, Lipcius et al. VIMS report in preparation). The current focus is on the Lynnhaven River system because of the naturally high oyster spat settlement on artificial reefs, the extensive multi-disciplinary research and information available for the system, and the cooperation of private citizens, citizen groups, private foundations, and federal and state agencies. For example, in July 2006 two artificial reef systems will be constructed in the intertidal and shallow subtidal zones fringing the properties of two homeowners. Three reef types will be used (smaller versions of the concrete modular reef in Figure 1, oyster shell reefs, riprap reefs) and quantified in terms of abundance of oyster, other invertebrates, and fish. This is indicative of the high level of cooperation displayed in the Lynnhaven River community, and thus, the likelihood of success of efforts aimed at increasing the production of oyster and recreational fish concurrently.

This proposal requests funds to measure the production of recreational fish and oyster on four types of subtidal artificial fish reefs. The proposal is part of a larger project aimed at determining an optimal reef design to enhance recreational fish and oyster production. The other critical element of the project concerns the prey base for recreational fish on these artificial reefs, which is presented in a complementary proposal by Seitz. The four reef types include (1) a multi-layer modular concrete reef of a design similar to that in Figure 1 but smaller, (2) oyster shell reef, (3) ReefBall reef, and (4) riprap reef. All four of these have been used in various locations to increase abundance of recreational fish and other species, yet their relative effectiveness has not been examined. The four reef types have different characteristics, and are therefore predicted to have varying effects on the abundance of recreational fish, on the prey base of recreational fish, and on oyster. Ultimately, we seek to determine which of the artificial reef types provides the most suitable shelter and feeding area for recreationally important fish and oyster. We will incorporate our findings with those of the complementary project by Seitz on the prey base for recreational fish species, and subsequently provide recommendations on the optimal reef design to increase recreational fish and oyster production in a network of artificial reefs throughout the waters of the Virginia portion of Chesapeake Bay. This project therefore falls under the category of Habitat Improvement, and secondarily under Research.

2.) **Objectives**

A) Evaluate recreational fish production on four types of artificial reefs within the Lynnhaven River System.

B) Evaluate oyster survival on the four types of artificial reefs.

C) In conjunction with the prey base and food web information from the complementary project by Seitz, determine the optimal reef type for maximizing recreational fish production and oyster abundance.

3.) **Expected Results or Benefits**

Successful completion of this project will result in identification of an optimal reef design that enhances recreational fish and oyster production simultaneously. Our group will work together with VMRC and CCA to determine the most effective means of implementing a network of artificial reefs that are protected from oyster harvesting, and which will thus serve as stable habitats providing food and shelter for recreational fish species. The recreational fishing community is expected to profit from the enhancement of fish production. In addition, we will implement an educational outreach program to work with the recreational fishers to help us collect some of the data, as well as requesting that they help to prevent illegal harvest of the oysters on the artificial reefs. Moreover, we already have commitments from oyster lease owners to allow us to construct the alternative reefs on their leases in Linkhorn Bay and Broad Bay within the Lynnhaven River system, pending permit approval by VMRC's Habitat Division. We have also been in contact with J. Travelstead and M. Meyers of VMRC's Fisheries Division to make sure that the artificial reefs are consistent with VMRC's philosophy on creation of artificial fish and oyster reefs. Finally, in the long term we hope to expand the project to other locations where these reefs can be used to augment production of recreational fish and oyster in a network of artificial reefs throughout the Virginia portion of Chesapeake Bay.

4.) **Approach**

At two locations within private oyster leases in Linkhorn Bay and Broad Bay, we will deploy three replicates of each of four reef types. The locations will be in approximately 3-5 m water depths just outside the navigation channels, and marked clearly with pilings according to VMRC/USCG standards. The four reef types will be randomly positioned in a circular layout to allow good water flow through the system, which reduces siltation, enhances recruitment of fish and invertebrates, and magnifies food delivery to the oysters and mussels on the reefs. The four reef types are:

a) 1.4 m x 1.4 m concrete modular reefs (Figures 3 and 4) consisting of 4 layers with 30-cm spacing between layers to provide shelter for fish.
b) Granite (rip rap) reefs of the same size.
c) Oyster shell reefs of similar size.
d) Reef ball fish habitats of similar size.

Reef structures will be deployed between March-April 2007 to allow for colonization by fish in the spring and summer, and by oysters and mussels in summer and fall. Abundance of fish, oyster and mussels (this project) and invertebrate prey (Seitz project) will be quantified in May, August and November 2007. The oysters, mussels and invertebrates will be sampled with 6-10 random 0.25 m x 0.25 m quadrats within each replicate reef type by removing all of the invertebrates with a scrape. This method has been used successfully in our previous field studies (Lipcius and Burke 2006). All oysters and mussels (this project) and other fauna (Seitz project) will be scraped into a mesh bag (1-mm mesh) and brought back to the lab for counting and weighing. Ash-free dry weight (AFDW) will be obtained by drying the organisms to a constant weight (~48 h) at 60°C, and ashed at 550°C for 4 h to obtain ash-free dry weight.

As described in the Seitz proposal, the collection of invertebrates at multiple sampling times (spring, summer, fall) permits estimation of annual production (g AFDW m^{-2} yr^{-1}) by use of the increment summation method (Downing and Rigler 1984) on the basis of the seasonal AFDWs. Fish production will be quantified with a combination of an underwater video system, direct diver observations, and selective capture of fish with circular nets used previously by us to sample artificial shelters in other locations. Most of the observations will be conducted with the video system, and verified with periodic diver observations and net sampling. These observations will give us direct measures of fish recruitment and foraging at each of the reef types. In addition, we will sample recreational fish at each location by enlisting the assistance of local recreational anglers through our contacts with Lynnhaven 2007 and the Coastal Conservation Association. During the spring, summer and fall sampling periods, we will work with 6-10 recreational anglers, who will be provided with a log book to record the numbers and sizes of fish caught at the reef sites. Periodically we will validate the size and abundance estimates of anglers by accompanying the anglers and taking direct measurements.

Production will be calculated by using published length-weight relationships. Although the angler information will not be specific to each reef type, the total production of the reef system will be ascribed to the reef types by partitioning the production according to the video and diver observations. The video system is a proven means of sampling fish under low visibility, as is diver observation. In the spring, we will refine the net sampling method and cross-validate it with the video and diver methods. The abundance of fish, oysters and mussels on the four reef types will be analyzed statistically (ANOVA models) to determine which reef type is optimal in enhancing fish, oyster and mussel production.

This project will be a collaboration among several entities and personnel, and leverage various sources of funding to decrease the cost to VMRC and the state:

VIMS—R. Lipcius will coordinate the project and interact with R. Seitz on the complementary food web/prey availability project, with H. Wang, J. Shen and M. Sisson on the existing hydrodynamic model for the Lynnhaven River system, and with M. Luckenbach and P.G. Ross on oyster abundance. R. Burke, a doctoral student at VIMS, will aid in coordination of the effort and use a portion of the information for thesis research, as will A. Lawless, an M.S. student of R. Seitz. A substantial portion of the graduate student costs is covered by other grants.

ACoE—D. Schulte and C. Seltzer of the Norfolk District are actively engaged in the project and have funded a portion of the pilot study for this proposal. In addition, the ACoE may be able to provide further funding for the construction of the reefs, offsetting the cost to VMRC and the state.

CBF—T. Leggett and C. Everett of the foundation's Virginia office are collaborating and covering some of the external costs of the project.

Lynnhaven 2007—This private-citizen group is facilitating interactions with homeowners and oyster lease holders, and providing an avenue of external private funding for the project.

City of Virginia Beach—The city is providing a boat slip at the city marina, and will fund some of the expenses of the project.

CCA—We will work closely with representatives of CCA (communications have been established with T. Powers) to ensure that the recreational angler community is fully aware of the project and aids in the data collection. We have already gained support from some of the local anglers, but we want to communicate with the broader community through CCA and Lynnhaven 2007.

VMRC—Lipcius has spoken with J. Travelstead and M. Meyers in the Fisheries Division to ensure that the proposed reef systems are in agreement with the goals and needs of the artificial reef program at VMRC. In addition, we will follow through on the formal permit process of the Habitat Division, as we have done recently for the shoreline reefs planned for deployment in 2006.

NOAA—The Chesapeake Bay Office has funded some of the pilot studies conducted with the Rappahannock River artificial reefs, and is funding pilot studies in the Lynnhaven River system.

5.) **Location**:

The Lynnhaven River system (Figure 5) has numerous ongoing investigations with extensive information on water quality and circulation patterns. A comprehensive oyster restoration effort is underway by the organizations noted previously, including VIMS. The lease sites are in areas that previously supported native oyster populations as indicated in the Baylor surveys, and where oyster spatfall has been consistent and abundant in recent decades. Consequently, we expect the oyster reefs to develop successfully and provide the community structure that supports the recreational fish inhabiting and utilizing the reefs for food and shelter. The reefs will be ad hoc oyster

sanctuaries since shellfish harvesting is prohibited within private oyster leases, except by lease holders. In the future, we will request that VMRC declare these reefs as oyster sanctuaries so that the integrity of the reef structure is not disrupted. In addition, a diverse assemblage of recreationally valuable fish is found in the Lynnhaven River system, making it an excellent model system for investigating the efficacy of artificial reefs in enhancing recreational fish production.

References

Cranfield HJ, Carbines G, Michael KP, Dunn A, Stotter DR, Smith DJ (2001) Promising signs of regeneration of blue cod and oyster habitat changed by dredging in Foveaux Strait, southern New Zealand. NZ J Mar Freshwater Res 35:897-908

Downing JA, Rigler FH (Eds). 1984. A manual on methods for the assessment of secondary productivity in fresh waters. Blackwell Publishers.

Lipcius RN, Burke R (2006) Abundance, biomass and size structure of eastern oyster and hooked mussel on a modular artificial reef in the Rappahannock River, Chesapeake Bay. VIMS Special Report in Applied Marine Science and Ocean Engineering No. 390

Peterson CH, Grabowski JH, Powers SP (2003) Estimated enhancement of fish production resulting from restoring oyster reef habitat: quantitative valuation. Mar Ecol Prog Ser 264:249–264

Seaman WS Jr (2000) Artificial reef evaluation with application to natural marine habitats. CRC Press, Boca Raton, FL.

Figure 1. Upper 3 layers of an alternative oyster reef that increased oyster density significantly (~1000 oysters m^{-2} of river bottom) and also enhanced recreational fish abundance (Lipcius and Burke 2006).

Figure 2. Close-up view of the alternative oyster reef, showing the diverse benthic community as well as the spaces that afford shelter and foraging areas for recreational fish species. Within the reef there were numerous fish and invertebrate prey, such as mud crabs, which are commonly eaten by structure-dependent (e.g., sheepshead) and transient (e.g., black sea bass) recreational fish (Seitz et al. manuscript in preparation). In the reefs that will be used in this project, the spacing of some of the layers will be increased to provide optimal shelter spacing and foraging areas for recreational fish.

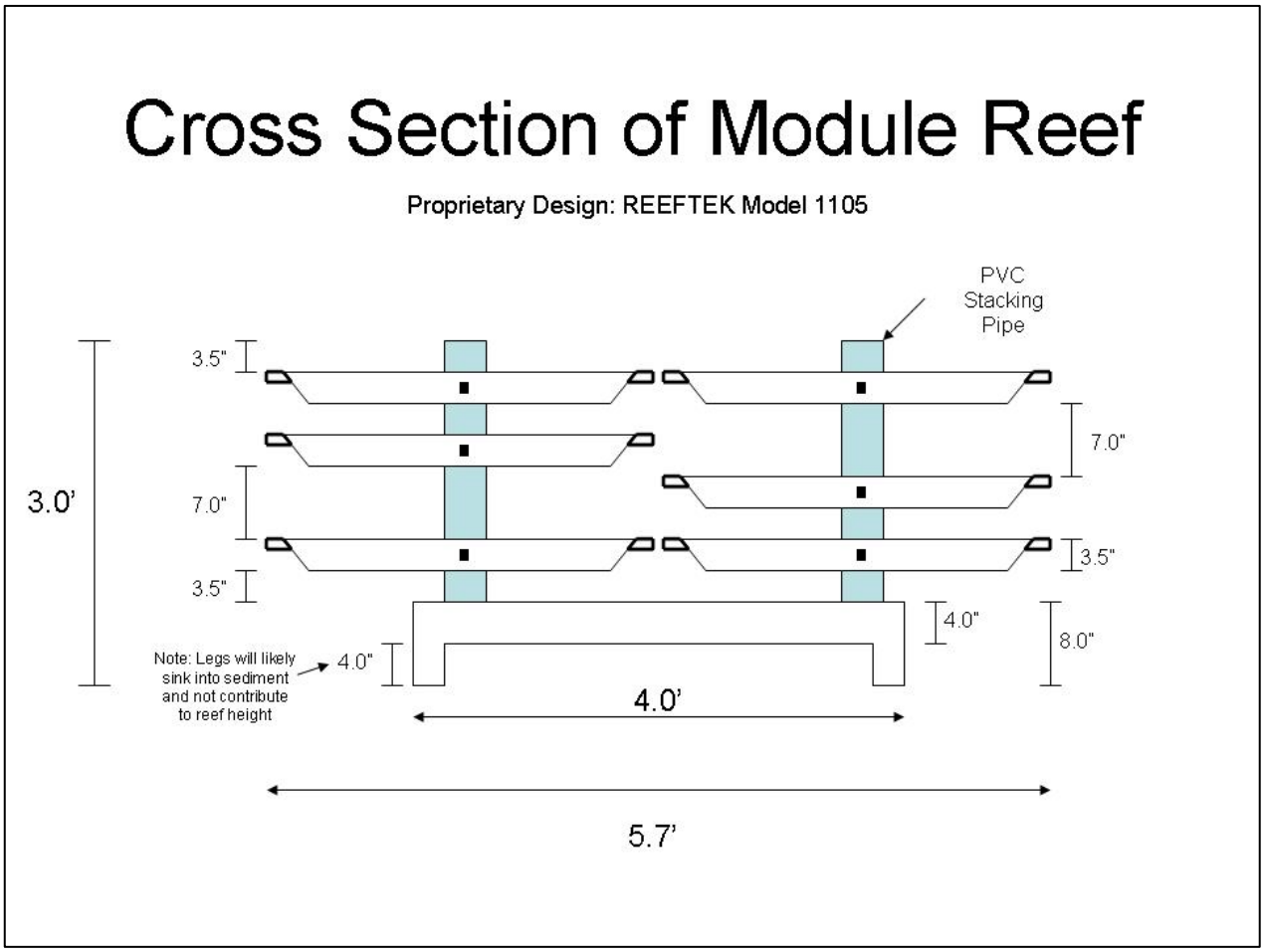

Figure 3. Cross section of the modular concrete reefs to be deployed in the subtidal zone of the oyster leases. The spacing has been adjusted to accommodate fish and oyster colonization and survival.

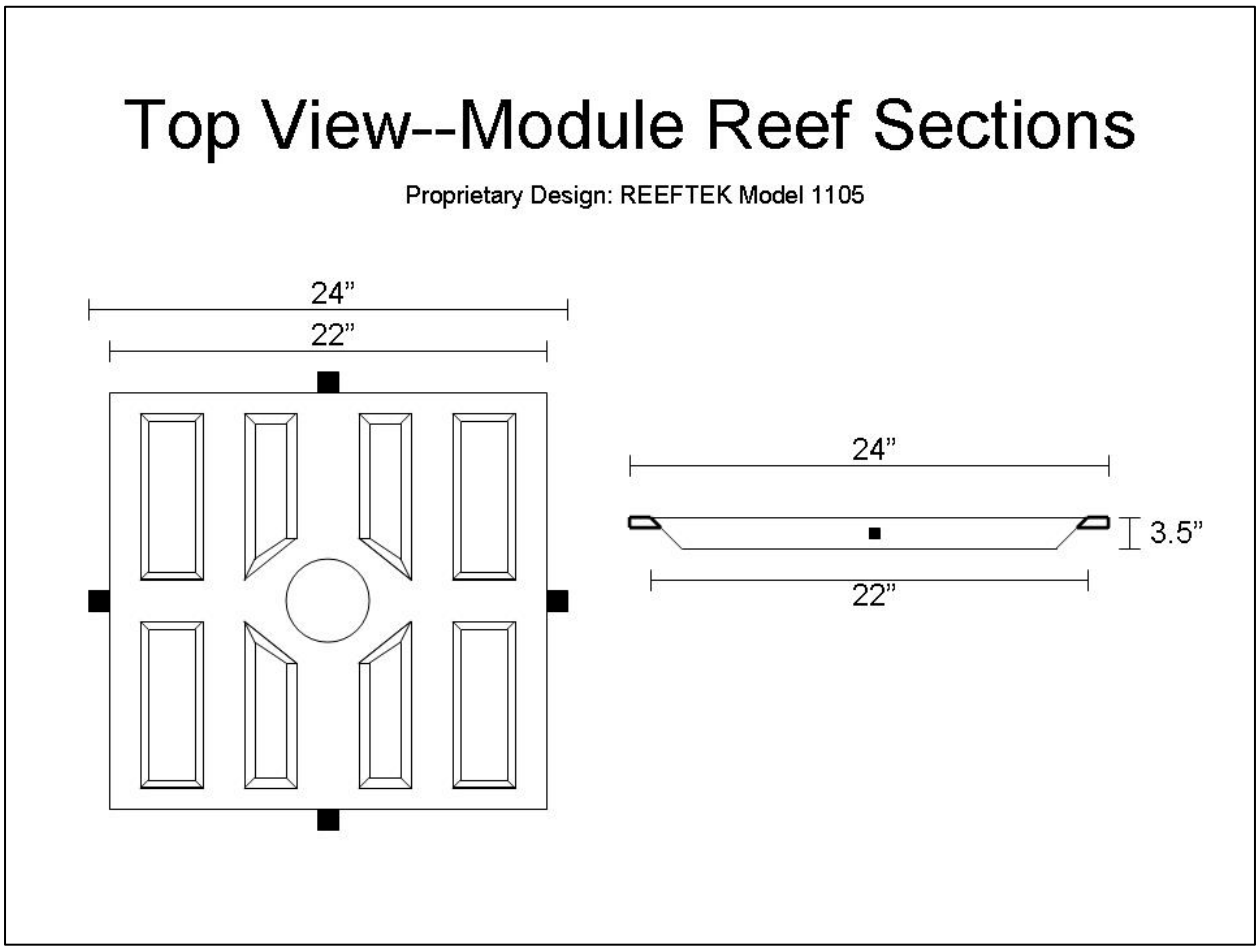

Figure 4. Top view of one of the four sections comprising each layer of the modular reefs. A four-layer reef will have a total of 16 such sections. The central hole guides the center pole that stabilizes each section. There are four such poles that support the four sections of each layer. The eight four-sided geometric shapes are actually sloped openings that increase the surface area for oyster and mussel settlement, and movement by fish between layers.

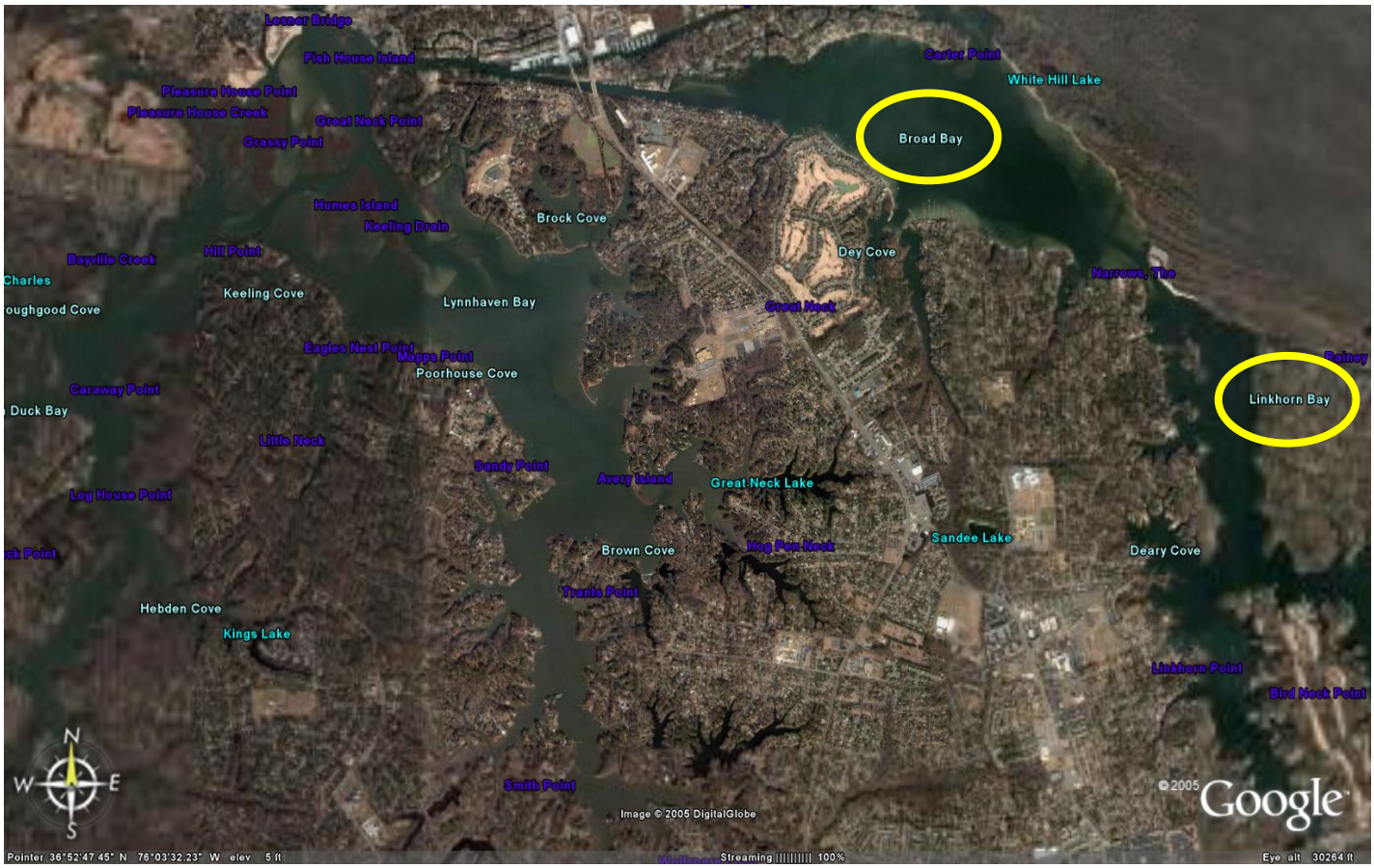

Figure 5. Locations of reef sites in Broad Bay and Linkhorn Bay within the Lynnhaven River system.

6.) **Estimated Cost and Justification**

	months	VMRC
Salaries		
Lipcius, PI - 1 months	1	8,583
Marine Scientist1 (BS level) - 12 months	12	30,228
Graduate Res Assistant (1 @ 12 months)	12	18,156
Fringe, 30% salaries; 7.65% waged		11,643
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Vessel Rental		
Rental - $120/day x 24 days	24 days	2,880
Subcontract		
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Equipment - 1 underwater video system for fish production estimation @ 28,000		28,000
Facilities & Administrative Costs		30,953
Total		199,643

Personnel salaries are for the coordination and conduct of the work. As leveraging, the salaries of two other staff and two additional graduate students will be covered under other grants. We have applied the allowable 30% fringe for faculty and 7.65% for hourly staff. We request 24 days of boat time on a VIMS vessel (large privateer) for sampling the reefs ($2880) plus fuel (listed in supplies). Supply costs include reef building materials, sampling materials, some SCUBA gear that will be used in this project and in future projects, software for the video system, and miscellaneous supplies. Supplies also include vessel fuel at $50 fuel per day for 24 days. Travel includes trucks for trailering boats from the VIMS main campus to field sites on the Lynnhaven Bay at 41 miles one-way (0.58 per mile x 2 ways= $47/day) for 24 days. In addition, we request $28,000 for a video system critical to estimate fish production, and which will be used in subsequent years with additional artificial fish reefs. The subcontract is for a small barge to deploy the reefs at the two locations. Indirect costs are charged at the rate of 25% with 20% match, with the exception of service center charges (vessels) and equipment.

Proposal Submission to

Virginia Marine Resources Commission

By

THE VIRGINIA INSTITUTE OF MARINE SCIENCE
COLLEGE OF WILLIAM AND MARY

Utility of Alternative Reefs to Simultaneously Enhance Recreational Fish Production and Oyster Restoration

Romuald N. Lipcius
Co-Principal Investigator

Rochelle D. Seitz
Principal Investigator

John E. Graves
Chair, Fisheries Science

Jane A. Lopez
Director, Sponsored Programs

Roger Mann
Director for Research and Advisory Services

June 15, 2006