M

VIRGINIA RECREATIONAL FISHING DEVELOPMENT FUND
SUMMARY PROJECT APPLICATION*

NAME AND ADDRESS OF APPLICANT:	PROJECT LEADER (name, phone, e-mail):
Virginia Institute of Marine Science P.O. Box 1346 Gloucester Point, VA 23062	Rochelle D. Seitz (804) 684-7698, seitz@vims.edu
PRIORITY AREA OF CONCERN:	**PROJECT LOCATION:**
Habitat Improvement & Research	Lynnhaven Bay, Virginia

DESCRIPTIVE TITLE OF PROJECT:

Prey Availability and Enhanced Production of Artificial Reefs for Recreational Fish and Native Oysters

PROJECT SUMMARY:

We request funds to monitor the production of various types of subtidal artificial fish reefs that attract large, structure-dependent fish, such as sheepshead and tautog, and which promote oyster settlement and survival. Specifically, we will investigate the effectiveness of these combined artificial fish/oyster reefs in enhancing local production of structure-associated recreational fish by examining the prey food base and predator-prey interactions through direct sampling of the reef invertebrates and fish gut-content analyses. We expect that at reef types where fish have adequate prey and feed upon intermediate predators of juvenile oysters (e.g., mud crabs), both the production of fish and oysters will be enhanced. Sampling of artificial reefs and fish diets, combined with mathematical modeling, will allow quantification of production.

EXPECTED BENEFITS:

Field sampling of the epibenthic fauna on these artificial reefs will give direct evidence of the community of prey for recreational fishery species that develop on these artificial reefs. A comparison of various reef structures will allow a quantitative understanding of ecological conditions beneficial to local recreational fishery species and their food-web interactions. We will document food-web interactions leading to increased production of the ecosystem that stems from deployment of these reefs, and a comparison among reef types in two habitats will identify key habitat characteristics that are beneficial for increased production. These studies will elucidate the performance of such alternative substrates in comparison to traditional reefs and identify optimal reef structures that maximize prey availability and increase recreational fish production.

COSTS:

VMRC Funding:	$ 45,944
Recipient Funding:	$ 6,751
Other Funding Sources (please list) **:**	NOAA/ACoE
Total Costs:	$ 52,695

Detailed budget must be included with proposal.

Updated 4/27/06

***This form alone does not constitute a complete application, contact Sonya Davis at 757-247-8155 or sonya.davis@mrc.virginia.gov**

Prey Availability and Enhanced Production of Artificial Reefs for Recreational Fish and Native Oysters

P.I.: R.D. Seitz

1.) **Need**

A. Introduction

Artificial reefs can enhance the production of recreationally important fish by providing habitat for structure-dependent fish (Seaman 2000) and by increasing prey availability for resident reef fish as well as for transient fish that forage on the reefs (Peterson et al. 2003a). The empirical means of estimating fish production on artificial reefs has been developed and used successfully to demonstrate enhanced production of fish with artificial reefs (Peterson et al. 2003a). There are various ways by which fish production is increased by artificial reefs. For example, if there is a bottleneck for survival of early life history stages of fish, then providing additional habitat (e.g., artificial fish reefs) is projected to cause increased recruitment of the species. Moreover, artificial reefs may provide additional food resources, via the reef-associated invertebrate prey, that may enhance growth of fish species associated with the reef (i.e., bottom-up control), or reefs can enhance fish survival by providing refuges from predation (Hixon 1998; Peterson et al. 2003a, b). If recruitment is limited by habitat area, additional reef habitat can result in increased fish production by improving habitat area, or by augmenting growth currently limited by reef refuges and associated prey such as mud crabs (Peterson et al. 2003a). Given these strong arguments in support of enhanced fish production with artificial reefs, it is typically recognized that such reefs can benefit recreational anglers who fish in the habitats in which the reefs are placed.

Bottom-up control of production has been demonstrated in several fisheries species. A combination of predation (i.e., top-down factors) and food limitation (i.e., bottom-up factors) likely influences species distributions in marine, freshwater, and terrestrial habitats, depending on aspects of the local food web (Posey et al., 1995; Menge et al., 1996). At broad spatial scales, bottom-up or physical factors may be more important than top-down factors (Power, 1992; Menge et al., 1997; Seitz and Lipcius, 2001). Additionally, bottom-up factors commonly drive freshwater systems (Brett and Goldman, 1996; Brett and Goldman, 1997). For instance, a recent study provided evidence for bottom-up control of an upper level omnivore (i.e., the blue crab) by its primary prey (i.e., the Baltic clam) (Fig. 1). Similarly, we expect that abundance of fish on artificial reefs will be directly related to the abundance of their prey on each specific type of reef.

Oyster restoration has achieved mixed results, with successful reefs in some locations but not others, and on some settlement substrates but not others. Recent evidence suggests that concrete reef structures support not only oysters (Lipcius and Burke 2006), but also many invertebrates that serve as prey (e.g., mud crabs, marine worms) for fish predators (Seitz et al. manuscript in preparation). Such concrete reefs are likely to enhance the productivity of recreational valuable fish in the area, yet such reefs have not been examined in Virginia waters as artificial fish reefs (e.g., in the Lynnhaven River system) where recreational fishing is prominent. A recent program to establish joint fish and oyster reefs in the Lynnhaven River system promises to benefit multiple user groups, namely saltwater fishers and those concerned with oyster restoration, and will serve as a model system for establishing such artificial fish/oyster reefs throughout Virginia waters.

We request funds to monitor the production of various types of subtidal artificial fish reefs that attract large, structure-dependent fish, such as sheepshead and tautog, and which promote oyster settlement and survival. Specifically, we will investigate the effectiveness of different artificial fish/oyster reefs in enhancing local production of structure-associated recreational fish. We will accomplish this by examining the prey food base and predator-prey interactions through direct sampling of the reef invertebrates and fish gut-content analyses. Prey of these recreational fishery species have been identified (Chesapeake Bay Fisheries Ecosystem Plan). We expect that at reef types where fish have adequate prey and feed upon intermediate predators of juvenile oysters (e.g., mud crabs), both the production of fish and oysters will be enhanced. Sampling of artificial reefs and fish diets, combined with mathematical modeling, will allow quantification of production. Ultimately, we will be able to determine which of the artificial reef types will provide the most food for recreationally important fish. We will then integrate our findings with those of the complementary project by Lipcius on fish production and oyster survival, and provide recommendations on the optimal reef design to increase recreational fish production.

Based on knowledge of food-web interactions (Chesapeake Bay Fisheries Ecosystem Plan), we hypothesize that on artificial reef substrates where fish have abundant prey and the benthic community provides high production value, the fish will have increased productivity. Moreover, where fish feed upon intermediate predators of juvenile oysters (such as mud crabs), oysters will survive and thrive. Field sampling of the epibenthic fauna on these artificial reefs will give direct evidence of the community of prey for fished species that develop on these artificial reefs. Mathematical evaluation of benthic production will allow quantification of food resources necessary for high fish production. This will allow a quantitative understanding of ecological conditions beneficial to local recreational fishery species and their habitat interactions. Our studies could elucidate the performance of such alternative substrates in comparison to traditional reefs and identify key environmental factors that lead to successful oyster restoration. Moreover, abundant invertebrate prey may be indicative of habitat quality and may be used to predict future successful placement of artificial reefs.

We intend to address the following major elements: (1) quantification of the production value of the prey community for recreational species on artificial oyster reefs; (2) monitoring of fish predators' diet choice on various reef types; and (3) determination of optimal reef substrate and placement for artificial reefs to maximize fish production.

Field sampling of the epibenthic fauna on these reefs will give direct evidence of the community of prey for recreational fishery species that develop on these artificial reefs. A comparison of various reef structures will allow a quantitative understanding of ecological conditions beneficial to local recreational fishery species and their food-web interactions. We will document food-web interactions leading to increased production of the recreationally valuable fish that stems from deployment of these reefs, and a comparison among reef types in two locations will identify habitat characteristics that are beneficial for increased production. These studies will elucidate the performance of such alternative substrates in comparison to traditional reefs and identify key environmental factors that lead to increased recreational fish production.

B. Artificial reef substrates

Often, artificial reefs serve a dual purpose, either as alternative fish or bivalve habitat or as an outlet for excess materials produced by industry (e.g. pelletized coal ash). For instance, at least 11 artificial reefs exist along the Italian Adriatic coast (Bombace et al. 2000). Seven of these serve as the best European examples to date of reefs that have provided successful commercial harvests, and which are used both by fishers and by aquaculturists (Jensen 2002). European countries have been experimenting with various types of artificial reefs over the last 30 years. Portonovo 1 reef was used for experimental work on suspended shellfish culture (mussels and oysters; Fabi and Fiorentini 1997). On this oyster reef, species richness, species diversity, and fish abundance increased after reef deployment (Fabi and Fiorentini 1994), particularly for reef-dwelling nekto-benthic species (e.g. Sparids and Sciaenids). Three years after deployment, the increase in average catch weight for these species was 10–42 times the initial values. The increment was positively correlated with reef dimension in terms of volume of immersed materials, and inversely correlated with distance between the oases. The reefs also had higher catch rates of reef-dwelling fish in comparison with unprotected areas, and seemed to be ‘‘buffered’’ against significant reduction compared to stocks in areas without reefs (Fabi and Fiorentini 1993). Thus, the preceding examples demonstrate that alternative reef structures providing the stability and complexity of natural reefs via development of adequate prey resources can lead to higher abundance, biomass and diversity of many species.

There is additional evidence of a successful modular reef structure in Chesapeake Bay that supports both oysters and recreational fish species. In October 2000, a substantial rebar-reinforced concrete modular reef was deployed subtidally (~7 m depth) near the mouth of the Rappahannock River, a western-shore tributary of Chesapeake Bay. A recent report (Lipcius and Burke 2006) quantified population structure, density, abundance, and biomass of Eastern oyster and hooked mussel, *Ischadium recurvum*, on this novel concrete modular subtidal reef. After the reef had been deployed for 4 ½ years, 120 stratified random samples were collected from various sections of the reef in May 2005. The reef had been colonized heavily by oysters and mussels, which recruited and survived at densities per m^2 of reef surface area ranging from 28-168 for oysters and from 14-2,177 for mussels. Additionally, the reef supported a multitude of additional prey resources such as mud crabs, polychaete worms, and small mollusks. Moreover, this reef supported sheepshead, tautog, striped bass, croaker and various other recreational fish. This 3-D modular reef structure apparently provides an architecture that is conducive for settlement, growth and survival of oysters and other prey for finfish. Therefore, such modular structures should be considered as a viable alternative reef structure. Given the documented success of modular reef structure, we aim to test the performance of this type of artificial reef for recreational fish as well as oysters.

Various reef types may enhance fish production by (1) providing shelter or (2) providing food (prey) for associated fish, however, some reef types may be able to provide both of those aspects. This study aims to address the latter aspect, by identifying the prey resources on various reef types, thus determining which of four experimental reef types contributes most to the production of recreational fish.

This project falls under the categories of both habitat improvement and research. The artificial reefs are designed to improve habitat for recreational fish species, and the accompanying research will identify the benthic production of various reef types and thus determine the optimal reef type to be used in the future.

2.) **Objectives**

A) Identify prey species on artificial reefs within the Lynnhaven River System.

B) Determine predator-prey interactions through gut-content analysis of structure-dependent reef fish.

C) Determine which of the various reef types provides the optimal carrying capacity for recreational fish.

3.) **Expected Results or Benefits**

Virginia's recreational fishermen will directly benefit during the experimental phase of this research project by having access to increased production of structure-dependent fishes on readily accessible artificial reefs that will be deployed in a companion project (Lipcius proposal).   Moreover, fishermen will benefit in subsequent years because this study will determine the optimal reef type and location for prey settlement and resultant high carrying capacity based on evaluation of prey resources on various reef types. The use of an experimental approach with replicates of each reef type in two locations will allow determination of the optimal habitat and substrate for future artificial reefs. For example, in previous studies on the benefits of artificial reefs, three years after deployment, the increase in average catch weight for certain fish species was 10–42 times the initial values.

4.) **Approach**

A) Experimental Design

In a companion study, two locations will be established and 3-4 replicates of four reef substrates for each artificial reef will be deployed (Fig. 2).

The four reef substrates include:

- i) 1.4 m x 1.4 m concrete modular reefs (Fig. 1) consisting of 4 layers with 30-cm spacing between layers to provide shelter for fish.
- ii) Granite (rip rap) reefs of the same size.
- iii) Oyster shell reefs of similar size.
- iv) Reef ball fish habitats of similar size (not pictured).

B. Field sampling – invertebrates

Before deployment of reefs, we will sample the infaunal invertebrates in the bare sediment in the reef footprint to establish a baseline productivity value for the each site. After deployment of reefs in March-April 2007, then during late spring, summer and fall, we will use a quadrat to excavate a 0.25 m x 0.25 m area within each replicate reef type by removing all of the potential food items (e.g., epifaunal invertebrates) with a scrape. All fauna will be scraped into a mesh bag (1-mm mesh) and brought back to the lab for counting and weighing. All invertebrates retained on the screen will be identified to the lowest possible taxonomic level (usually species), measured, and frozen for biomass estimates. To obtain ash free dry weight (AFDW), invertebrates will be dried to a constant weight (~48 h) at 60°C, and ashed at 550°C for 4 h to obtain ash weight. Through collection of invertebrates at multiple sampling times (spring, summer, fall) we can estimate annual production (g AFDW m^{-2} yr^{-1}) by use of the increment summation method (Downing and Rigler 1984) on the basis of AFDWs quantified. In the companion Lipcius proposal, 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. Subsequently, we will statistically compare the abundance of fish prey on the four reef types, and determine which reef type is optimal in terms of providing food for recreationally important fish species.

C) Predator-Prey interactions – gut contents

Our first choice is to work with the recreational fishers within the Lynnhaven 2007 community group to collect stomachs from fish that they have collected. In the event that we are not able to collect sufficient fish samples, we will collect fish from the artificial reefs with hook and line. Fish will be frozen immediately upon capture and stomachs will be removed either in the field or in the laboratory and immersed in preservative. The gut processing protocol is as follows:

1) Contents of each stomach are emptied and each prey item is identified to the lowest possible taxonomic level (usually species).
2) After identification, each prey item is counted, weighed, and measured. We will then calculate diet indices such as %Weight, %Number, %Frequency, and %IRI (index of relative importance).

As noted in the companion Lipcius proposal, 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. Seitz will coordinate the project and interact with R. Lipcius on the complementary fish and oyster production 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. A. Lawless, an M.S. student, will aid in coordination of the effort and use a portion of the information for thesis research. 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 is a well-studied system where data on water quality and hydrodynamics are readily available. The Lynnhaven River is small tributary on the southern shore of the Chesapeake Bay. This system supports a large recreational fishery for multiple species. Moreover, it has been chosen as an oyster restoration zone because it has supported oyster populations in recent years and had a history of regular spat settlement and significant private oyster production. We know that this system experiences predictable, high settlement of oyster larvae and is thus a prime location for field experiments that require natural settlement (Fig. 3). Reefs will be deployed in two locations, one in Broad bay and one in Linkhorn bay on landowners' leased grounds, after proper permitting has occurred.

Field sampling of the epibenthic fauna on these artificial reefs will give direct evidence of the community of prey for recreational fishery species that develop on these artificial reefs. A comparison of various reef structures will allow a quantitative understanding of ecological conditions beneficial to local recreational fishery species and their food-web interactions. We will document food-web interactions leading to increased production of the ecosystem that stems from deployment of these reefs, and a comparison among reef types in two habitats will identify key habitat characteristics that are beneficial for increased production. These studies will elucidate the performance of such alternative substrates in comparison to traditional reefs and identify optimal reef structures that maximize prey availability and increase recreational fish production.

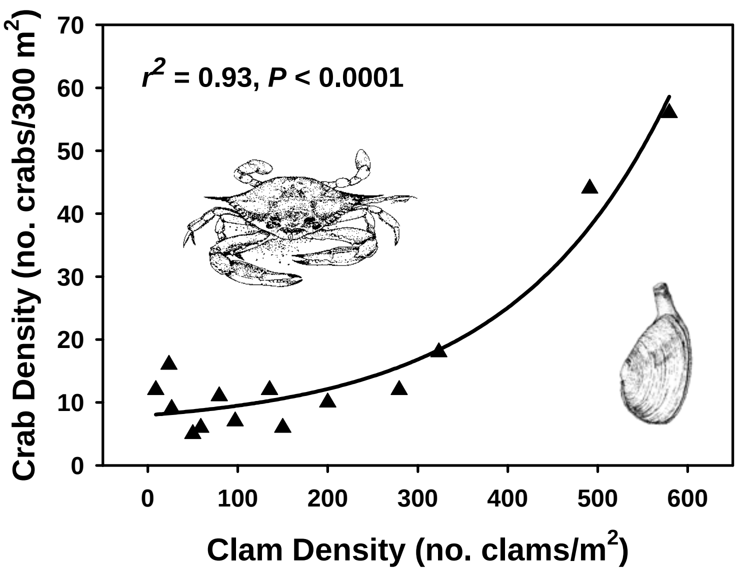

Figure 1. Crab density versus clam density for multiple sites in York River (Seitz et al. 2003).

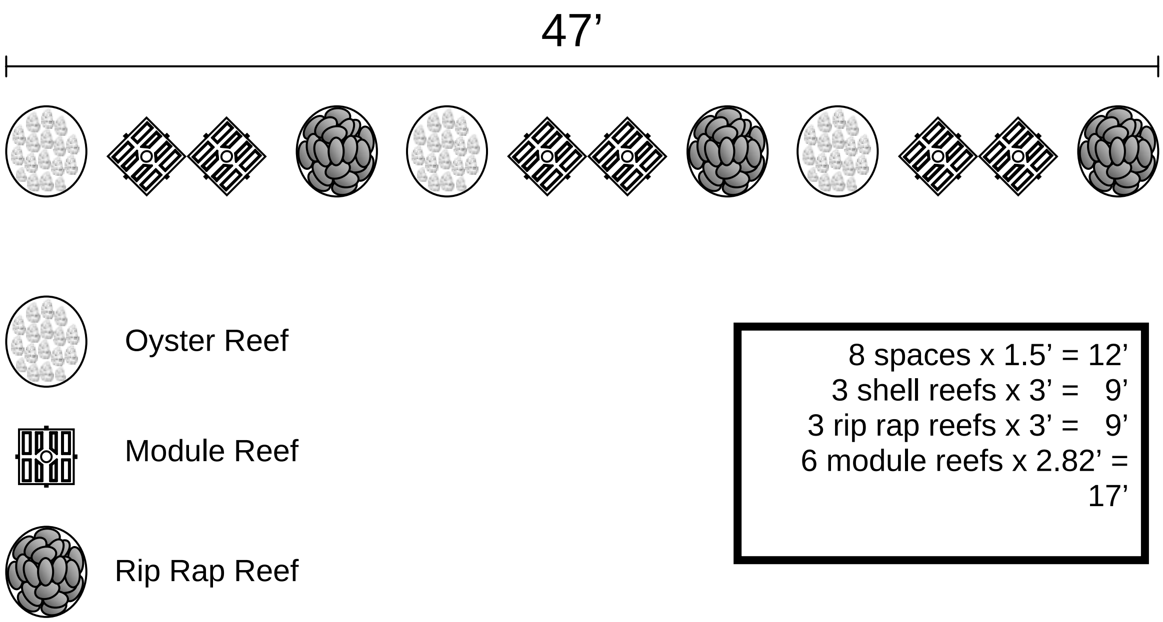

Figure 2. Example of experimental layout of 3 of 4 artificial reef types. Deployment will be in a circular framework instead of linear.

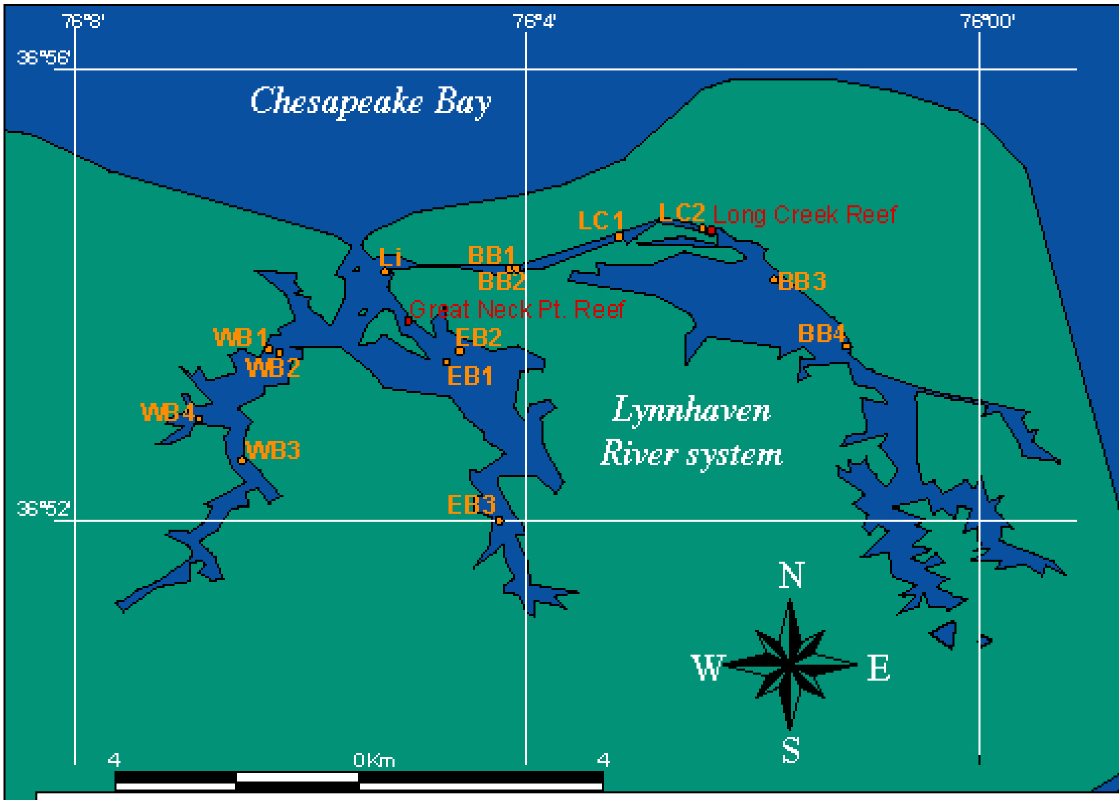

Figure 3. Lynnhaven Bay system with locations of spat fall survey by VIMS researchers. Broad and Linkhorn bay are on upper and lower right, respectively.

References:

Bombace G, Fabi G, Fiorentini L (2000) Artificial reefs in the Adriatic Sea. *In* Artificial Reefs in European Seas, 31-64. Ed. by AC Jensen, KJ Collins, and APM Lockwood. Kluwer. 508 pp

Brett, MR, Goldman CR (1996) A meta-analysis of the freshwater trophic cascade. Proceedings of the National Academy of Sciences of the USA 93:7723-7726.

Brett, MR, Goldman CR (1997) Consumer versus resource control in freshwater pelagic food webs. Science 275:384-386.

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

Fabi G, Fiorentini L (1993) Catch and growth of *Umbrina cirrosa* (L.) around artificial reefs in the Adriatic Sea. Boll Oceanol Teor Applic 11:235-242

Fabi G, Fiorentini L (1994) Comparison of an artificial reef and a control site in the Adriatic Sea. Bull Mar Sci 55:538-558

Fabi G, Fiorentini L (1997) Molluscan aquaculture on reefs. *In* European Artificial Reef Research, 123-140. Ed. by AC Jensen. Southampton Oceanography Centre. ISBN 0-904175-28-6. 449 pp

Grossman GD, Jones GP, Seaman WJ Jr (1997) Do artificial reefs increase regional fish production? A review of existing data. Fish Manag 22:17–23

Hixon MA (1998) Population dynamics of coral-reef fishes: controversial concepts and hypotheses. Aust J Ecol 23:192–201

Jensen, AC (2002) Artificial reefs of Europe: perspective and future. ICES J Mar Sci 59:S3-S13

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

Menge, BA, Daley B, Wheeler PA, and Strub PT (1997) Rocky intertidal oceanography: An association between community structure and nearshore phytoplankton concentration. Limnology and Oceanography 42:57-66

Nestlerode JA (2004) Evaluating restored oyster reefs in Chesapeake Bay: How habitat structure influences ecological function. PhD dissertation Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, Virginia

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

Peterson CH, Kneib RT, Manen CA (2003b) Scaling restoration actions in the marine environment to meet quantitative targets of enhanced ecosystem services. Mar Ecol Prog Ser 264:173–175

Power, ME (1992) Top-down and bottom-up forces in food webs: do plants have Primacy? Ecology 73:733-746

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

Seitz, RD, Lipcius, RN, Hines, AH, Eggleston DB (2001) Density-dependent predation, habitat type, and the persistence of marine bivalve prey. Ecology 82 (9), 2435-2451

Seitz, RD, Lipcius RN, Stockhausen WT, Delano KA, Seebo MS, Gerdes PD (2003) Potential bottom-up control of blue crab distribution at various spatial scales. Bulletin of Marine Science 72 (2): 471-490

6.) **Estimated Cost and Justification**

	months	VMRC
Salaries		
Seitz, PI - 1 month	1	5,283
Technician (BS level) - 7 months	7	18,000
Fringe, 30% salaries; 7.65% waged		2,962
Supplies		
Boat fuel, bags, jars, chemicals, labels		5,600
Travel		
Domestic to field sites @$.58/mile VIMS truck		1,410
Vessel Rental		
Rental - $125/day x 30 days	24 days	3,750
Publication and dissemination		500
Facilities & Administrative Costs		8,439
(plus an additional $ 6,751 as match)		
Total from VMRC		45,944

Brief Project Budget Justification

The Project Director Seitz, will oversee and manage the project, sample collection, and data analyses. We are requesting funds for one month of salary ($5,283/mo). We include 7-months support for an hourly technician at VIMS ($2570/mo) to sample invertebrates on the replicate reef structures, and to conduct gut-content and production analyses. We apply the allowable 30% fringe for faculty, 7.65% for hourly staff.

We request 30 days of boat time on a VIMS vessel (large privateer) for sampling of all reef types and fish collection for diet analysis (2 work weeks for each of 3 months in summer). This vessel costs $125/day x 30 days (= $3750) plus fuel (listed in supplies).

Supply costs including vexar baskets for supporting movable reef structures ($2,000)(these will be moved for sampling) sieves, formalin preservation chemicals, glassware, and forceps ($1,600), suction sampling bags and other field sampling supplies ($500) totaling $4,100. Supplies also include vessel fuel: 30 boat days @ $50 fuel per day ($1500).

Travel includes trucks for trailering boats from the VIMS main campus to field sites on the Lynnhaven Bay at 41 miles away (0.58 per mile x 2 ways= $47/day) for 30 days

($1,410). In addition, we request $500 in all years for publication and dissemination costs including journal page charges and public relations printing/artwork support. Indirect costs are charged at the rate of 25% with 20% match, with the exception of service center charges (vessels) and equipment. The total funds requested from the Virginia Marine Resources Commission Recreational Fishing License board are $45,944, with $ 6,751 in match, totaling $ 52,695 for the project.

Proposal Submission to

Virginia Marine Resources Commission

By

THE VIRGINIA INSTITUTE OF MARINE SCIENCE
COLLEGE OF WILLIAM AND MARY

Prey Availability and Production of Artificial Reefs for Recreational Fish and Oysters

Rochelle D. Seitz
Principal Investigator

Romuald N. Lipcius
Co-Principal Investigator

J. Emmett Duffy
Chair, Biological Sciences

Jane A. Lopez
Director, Sponsored Programs

Roger Mann
Director for Research and Advisory Services

June 15, 2006

VIRGINIA INSTITUTE OF MARINE SCIENCE
TITLE: Prey Availability and Production of Artificial Fish and Oyster Reefs

Duration (months): 12 Months

PRINCIPAL INVESTIGATOR:
Rochelle D. Seitz

	No People	Amount Effort	Rec Lic Funds	Match	Total Funds
A. SALARIES AND WAGES:					
1. Senior Personnel					
a. Principal Investigator:	1	1	5,283		5,283
					0
2. Other Personnel					
a. Professionals:					
b. Research Associates:					
c. Res. Asst./Grad. Students:					
d. Prof. School Students:					
e. Pre-Bachelor Student(s):					
f. Secretarial-Clerical:					
g. Technicians:	1	7	18,000		18,000
h. Marine Scientist Sr.					
Total Salaries and Wages:	2	8	23,283		23,283
B. FRINGE BENEFITS:			2,962		2,962
Total Personnel (A and B):			26,245		26,245
C. PERMANENT EQUIPMENT:					0
15 concrete reef modules					
D. EXPENDABLE SUPPLIES AND EQUIPMENT:			5,600		5,600
Reef baskets, bags, jars, preservation chemicals, labels					
E. TRAVEL:					
1. Domestic			1,410		1,410
2. International			0		0
Total Travel:			1,410		1,410
F. PUBLICATION AND DOCUMENTATION COSTS:			500		500
G. OTHER COSTS:					
Boat Time and fuel			3,750		3,750
Total Other Costs:			3,750		3,750
TOTAL DIRECT COST (A through G):			37,505		37,505
INDIRECT COST (25 % allowed; 45% VIMS approved rate):			8,439	6,751	15,190
TOTAL COSTS:			45,944	6,751	52,695