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Norfolk Canyon Marine Sanctuary resources study plan : final report

Virginia Institute of Marine Science

NORFOLK CANYON
MARINE SANCTUARY
RESOURCES STUDY PLAN

Final Report

Developed by

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for the

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M. P. Lynch

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TABLE OF CONTENTS

RESOURCES STUDY PLAN

NORFOLK CANYON MARINE SANCTUARY

Establishment of a Norfolk Canyon Marine Sanctuary provides the framework necessary to examine the biological, geological, and hydrographic processes functioning in submarine canyon systems and to improve the basis for management decisions related to exploitation of East Coast submarine canyons.

Research in submarine canyons is not an easy task. Although there are nearly 100 submarine canyons between Cape Hatteras and Nova Scotia, Norfolk Canyon, the canyon closest to the coast, is approximately 100 km from the nearest landfall. The Canyon begins at about the 80-100 m isobath contour and extends to a depth of more than 2000.

Research on Canyon processes and resources requires considerable logistic support involving surface vessels, submersibles, remote operating vehicles and extensive "state of the art" oceanographic instrumentation.

A. Overview

The Resource Study Plan is strongly interdisciplinary. Biological, geological and physical processes interact in canyon areas in such a manner that one process cannot be effectively studied in isolation from others. To develop the Research Plan, however, research priorities have been developed by discipline. The implementation phase of the Research Plan (Part D), however, does recognize the need for an interdisciplinary approach to field studies in the region.

The plan has three primary foci: Biological Studies, Geological Studies, and Physical (including Meteorological) Studies. A limited pollution monitoring program is also proposed. To support these areas and to provide immediate information to responsible management

agencies, two additional areas have been identified: Data and Information Management, and Socio-Economic Studies. In both of these support areas a number of projects have been identified which will have direct relevance to interpretation (educational) and recreational plans.

B. Resource Studies

1. Physical Oceanography

Central to understanding the movement and exchanges of water (and associated constituents such as suspended sediments, plankton, etc.) into, out of and within submarine canyons is the identification and quantification of dominant length and time scales of processes which affect these regions. Determination of these time scales will lead to physical process definition and permit investigators to hypothesize relevant parameters necessary to model and explain these processes.

Processes which have been hypothesized as important have temporal scales ranging from less than hourly (internal waves) to annual (seasonal heating) and incorporate aperiodic perturbations or "events" such as the passage of large storms or anticyclonic Gulf Stream rings.

A three part program of physical studies is recommended for Phase 1.

a. Meteorological Studies

Historical records of wind, air temperature, wave, fog and cloud cover are summarized for a 50,000 km^2 area encompassing Norfolk Canyon, (Region 08 SSMO - Summary of Synoptic Meteorological Observations, NTIS). Similar summaries are available for areas encompassing or adjacent to other east coast submarine canyons. The SSMO's are compiled from meteorological observations made by ships passing through an area, and consequently, they provide minimal information on

storms or severe weather. The storm avoidance effect may be somewhat lessened at Norfolk Canyon, however, because many of the ships are entering or leaving Chesapeake Bay, and so cannot deviate far from the Norfolk Canyon when in the area. Climatological analysis of meteorological data can best be made, however, when the data are collected at regular intervals at fixed stations. The National Oceanic and Atmospheric Administration (NOAA) presently does this for ocean areas from fixed shallow water platforms (light towers) and buoy stations in deeper waters.

The present location and spacing of east coast stations is insufficient to provide adequate meteorological data (particularly wind) for use in studies intended to relate circulation to wind forcing in any of the east coast canyons.

The present fixed meteorological stations closest to Norfolk Canyon (Chesapeake Light Tower near 37°N, 76°W and NOAA Buoy 41001 at 35°N, 73°W) are too distant from the Canyon head to provide the long term meteorological records necessary to understand the canyon's circulation. An appropriate location for meteorological stations should be within 50 km of the canyon head.

Action - Establish a minimum of two continuing meteorological stations (one shelf, one slope) within 50 km of Norfolk Canyon to obtain wet and dry bulb air temperature and surface water temperature, atmospheric pressure and wind velocity data on a regular basis (one to three hour periods). Data from these stations will be used to develop a detailed climatology for the region and a wind profile for wind forced circulation studies. In addition, a review should be made of individual ship reports used in developing SSMO reports to determine if data points from the immediate vicinity of Norfolk Canyon are of sufficient density during different weather conditions to be useful in

developing a detailed climatology.

b. Hydrographic and Circulation Studies

The study of physical oceanography of east coast submarine canyons is in its infancy. Individual studies in canyons between Georges Bank and Cape Hatteras (reviewed by EG&G, 1983) indicate existence of both similarities and differences in the few canyons investigated thus far. A statement in EG&G (1983), "...there should exist a set of simple, universal physical principles underlying and governing water motions within submarine canyons...it should not be necessary to treat canyon processes as a series of incoherent, random processes," captures the general agreement among those oceanographers concerned with canyon processes. The EG&G (1983) report goes on to state that studies to elucidate these principles "...should be designed to study a single phenomenon in a single canyon in a manner that encompasses all the relevant physics.

Three projects are proposed in this study area.

1) Circulation and Water Structure

Most circulation and water structure studies have the common denominator of dominant and relevant length and time scales. These scales should be estimated through theoretical studies based on existing data and results of field experiments.

Action - Determine, through analysis of existing data and field experiments, the dominant and relevant length and time scales of physical processes in and around Norfolk Canyon including the adjacent shelf and slope regions. Field experiments will involve obtaining long-term (multi-annual) current and temperature/salinity records in and near the canyon. NOTE: Long-term records of currents and temperature/salinity along the canyon axis will be

difficult to obtain because moorings will require periodic servicing and replacement. If replacement is required, limited confines of the canyon will require near exact replacement guided by a submersible or underwater acoustic beacons (similar to wellhead recovery equipment used by drilling companies). Both procedures are expensive and the former has the additional constraint of requiring favorable weather conditions. Initial cruises to the area should evaluate the use of expendable current probes to describe "instantaneous" current regimes. If successful, these probes should be used routinely on subsequent cruises.

2) Internal Wave and Tide Energy

Focusing of internal wave and tide energy by submarine canyons has been demonstrated in Hudson Canyon by Hotchkiss (1980, 1982); as well as Hotchkiss and Wunsch (1982). Their experiments show that internal tides generated in the canyon by surface tides are focused toward the canyon head and downward resulting in enhanced erosion and suspension of sediment. Geological and biological consequences of this process are evident in Hudson Canyon. The extent of this phenomenon in Norfolk Canyon should be determined so its impact on canyon geology and ecology can be evaluated.

Action - Data obtained for circulation and water structure studies are useful for this type of investigation. They should be augmented with hydrographic surveys (closely spaced Conductivity-Temperature Depth (CTD) stations within and around the canyon) to identify pynocline strength and depth. NOTE: Hydrographic surveys can be combined with biological, geological or moored instrument maintenance cruises. Hydrographic data in and around Norfolk Canyon are scarce, hence all cruises to the region should be scheduled with 2-4 days available for occupation of CTD and

Expendable Bathythermograph (XBT) (and if feasible expendable current probe) stations. A series of permanent XBT/CTD stations should be established with the requirement that they be occupied both at the beginning and end of each cruise to the canyon.

3) Wind Forcing

Axial flow in canyons is, in some instances, responsive to wind forcing. The process may be important in the exchange of shelf and slope water in canyons. Wind induced barotropic pressure gradients on the continental shelf appear to induce axial flow in canyons which is ageostrophic. One reaction within the canyon is the establishment of a balancing baroclinic pressure gradient resulting in axial motion in the canyon that is in phase with wind and along shore shelf currents (EG&G, 1983).

Action - A study should be undertaken of wind, shelf and canyon currents and shelf, canyon and slope hydrographic conditions to establish the importance of wind induced shelf/slope water exchanges through canyons.

c. Gulf Stream - Canyon Interactions

Review of early Experimental Frontal Analysis charts produced by the U. S. Navy and later, similar charts furnished by NMFS/NOAA, indicate a frequent tendency of anticyclonic Gulf Stream rings to migrate and remain in the vicinity of Norfolk Canyon for extended periods (from one to several weeks). Although EG&G (1981) found that shelf water at a depth of 135 m responded to the presence of an anticyclonic ring in the vicinity of Tom's Canyon, currents in the canyon at 550 m showed no response to this transient feature. Ruzecki (1979) suggests, however, that on some occasions, intrusions of warm saline water into Norfolk Canyon may be in response to anticyclonic rings, if not directly, then as a

secondary effect from entrainment of Gulf Stream streamers by the rings.

Action - Determine the frequency and duration of anticyclonic Gulf Stream ring encounters with Norfolk Canyon and, through analysis of current and hydrographic data, determine their effect on circulation in the canyon.

2. Geological Oceanography

Bathymetry and gross physiography of Norfolk Canyon have been detailed by Wear et al. (1974) and Forde (1981). As the result of these studies, accurate, large-scale, high-resolution bathymetric charts of Norfolk Canyon are available. Bedrock geology in Norfolk Canyon has not been studied in detail. However, comprehensive investigations of selected New England submarine canyons (Ryan et al., 1978) have provided a basis for interpreting the origins, age, stratigraphy, composition, and erosion of lithographic strata in Norfolk Canyon. The large number of outcrops in Norfolk Canyon could provide a relatively easy view of its bedrock geology. Geologically young unconsolidated sediments in Norfolk Canyon have been studied by Forde et al. (1981). The result of these various studies is a general understanding of major large-scale geological features of Norfolk Canyon. Small-scale geological features of particular relevance to the canyon biota have been noted and briefly discussed based on submersible observations in Norfolk, Oceanographer and Hudson canyons.

Phase 1 of geological research in Norfolk Canyon Sanctuary should concentrate on description of small-scale geomorphological features and local sedimentary regimes of relevance to the canyon biota. Classical, descriptive analysis of large-scale bedrock geology is given a lower priority relative to intensive, localized investigations emphasizing the ecological role of geological features. Comprehensive large-scale stratigraphic description of

the canyon requires a great deal of expense particularly in logistic support (i.e. submersibles or ROV's) yet contributes very little to the understanding of fine-scale structure and processes of significance in the contemporary ecological context.

The head of Norfolk Canyon between depths of 100 and 1000 meters is topographically and structurally more complex and biologically more heterogeneous than the lower reaches of the canyon, but its proximity to shore provides relatively easier access, which along with the economics involved in use of shallow versus deep submersibles makes it logical that Phase 1 of geological investigations should begin in and concentrate upon the canyon head. Subsequent stages may then proceed systematically to greater depths.

a. Hard Substrate Studies

Investigation of the origin, distribution, and unique characteristics of various hard substrate regimes which can be related to characteristic biotopes is a high priority. Included are such regimes as vertical rock walls, platform terraces, large isolated erratic boulders, avalanche boulder rubble fields, and outcrops of maleable (to large burrowing animals) clay or mudstone. Hard-bottom biotopes offer three-dimensional environmental heterogeneity, by promoting colonization of the bottom by sessile organisms which require hard substrate for attachment and mobile epifaunal and benthopelagic organisms which require physical shelter. Thus, hard substrate regimes support a higher density and greater diversity of large megafaunal species than do soft substrate areas at comparable depths.

Action - Conduct an analysis, description and characterization of the various hard substrate regimes in Norfolk Canyon. This should be undertaken in coordination with biological studies of the biota characteristic of particular hard substrate biotopes.

b. Soft Substrate Studies

Playing a less conspicuous, but perhaps no less significant, ecological role than hard substrate regimes are the various soft substrate regimes in the canyon. The nature and quality of bottom sediments (grain size, sorting, water content, organic carbon content, etc.) determine the composition and population density of the infaunal macrobenthos (e.g., polychaetes, amphipods, bivalve mollusks). In turn, the mosaic pattern of distribution of various components of the soft substrate megafauna (e.g., asteroids, echinoids, cerianthid anemones, pennatulids) probably depends either directly or indirectly upon local sediment texture. Thus, the patchy and bathymetrically irregular distributions of the invertebrate megafauna may be indicative of patchy sedimentary regimes. Although soft substrate regimes have been poorly characterized in submarine canyons, some characteristic megafaunal assemblages can already be specified in certain cases. For example, a hermit crab-gastropod assemblage is typical of the axial regime of Norfolk Canyon at lower slope to upper rise depths. In general, however, the nature of various soft substrate sedimentary regimes and their associated biotas remains poorly understood.

Action - Conduct an analysis, description and characterization of the various soft substrate regimes. This should be undertaken in close coordination with descriptive and quantitative studies of the macro-benthic infauna and epifauna. Sampling should also be coordinated with recognizable assemblages of megafaunal invertebrates. Indeed, the distribution of megafaunal species may serve as an empirical guide to the locations of sediment sampling sites.

c. Geographic and Bathymetric Mapping

In addition to the analysis, description and

characterization of the hard and soft bottom substrate biotopes, the location and extent of the individual patches should be determined. This information should be incorporated into a detailed data base which could be used in generating maps of the Canyon and adjacent shelf/slope regions.
Action - Build a geographic and bathymetric data base of the Norfolk Canyon and adjacent shelf/slope region capable of incorporating geo-locations of specific substrate related biotopes and couple this data base to a graphics system capable of generating both plane and multidimensional maps. NOTE: Although this project is described here, it should be considered as an integral part of the Data and Information Management Program as described later and not restricted to the presentation of geological maps.

3. Biological Studies

While our knowledge of the biota of submarine canyons has advanced considerably over the past decade (see EG&G 1983), it nonetheless remains in a preliminary state. Emphasis of biological research has to date been dedicated primarily toward identification and inventory of large and conspicuous demersal fishes and invertebrates characteristic of particular depth strata within canyons. Scientists have barely begun to address the more significant research topics related to the processes contributing to the unique nature of canyon fauna. This requires an interdisciplinary approach encompassing underlying geological and physical processes. While a few investigations have been initiated in recent years on biota-substrate relationships only a limited number of well-circumscribed benthic biotopes have received attention. Comparable investigations of biota-watermass relationships for pelagic canyon fauna have yet to begin.

a. Benthic Biological Studies

Previous investigations of the benthic macrofauna,

megafauna, and demersal fish fauna of Norfolk Canyon, other East Coast canyons, and adjacent regions of the slope and rise have concentrated on descriptive inventory of species, bathymetric zonation, and trends with depth in diversity, biomass, and numerical abundance (see EG&G 1983). All of these investigations have employed remote sampling gear lowered or towed from a surface vessel. As such gear cannot generally be employed in structured relief hard substrate areas, remote sampling has been confined mostly to even relief, soft substrate areas. Consequently, we have a reasonably complete faunal list for large invertebrates and demersal fishes inhabiting soft substrate areas of Norfolk and other East Coast canyons. Our knowledge of the fauna of hard substrate areas is very incomplete. Additional problems using remote gear for benthic investigations include avoidance and escape by mobile organisms, imprecise positioning of samples within specified types of habitats, and observational scales that are often either too large (trawls) or too small (cores, grabs, bottom photographs) to match the scale of community heterogeneity.

A small number of biological investigations in East Coast canyons and adjacent regions (see EG&G, 1983) have employed submersibles for direct in situ observations of selected taxa. None of these investigations, however, involved Norfolk Canyon. Incidental biological observations have resulted from geological investigations using submersibles. Some of these discuss bioerosion and sediment reworking by animals in Norfolk Canyon. However, as with geological investigations, submersible biological investigations have proceeded in piecemeal fashion in diverse localities and at diverse depths. To date the systematic use of submersibles to investigate, characterize, and sample bottom communities in submarine canyons has been very limited. Little advantage has been taken of the unique capability of submersibles to deploy and conduct

long-term *in situ* biological experiments in canyons.

A limited number of life history studies (growth, feeding, reproduction) have been made on selected taxa based on remotely obtained material from Norfolk Canyon. However, nothing has as yet been published concerning species life histories or the ecology of bottom communities in Norfolk Canyon as the result of submersible investigations. Furthermore, considering the published results of all submersible investigations conducted to date in East Coast canyons, very little observational data is available concerning the ecology, behavior, or life histories of most canyon inhabitants.

1) Hard Substrate Faunas

Initial emphasis should be given to the faunas of the presently poorly sampled hard substrate biotopes. The studies should emphasize direct observations and *in situ* experimental studies conducted with submersibles. Investigations should focus initially on identification and characterization of various assemblages of species such as benthic invertebrate macrofauna, epibenthic invertebrate megafauna, bentho-pelagic microfauna and demersal fish fauna. Phase 1 studies should concentrate on the canyon head and upper and middle slope (100-1000 meter depth range).

Action - Identify, characterize and quantitatively describe the faunas of hard substrates in the Norfolk Canyon. This should be undertaken in coordination with geological studies of hard substrate regimes. These studies should address population densities, numerical dominance, order of species, trophic relationships, species interactions, behavior patterns and substrate requirements.

2) Soft Substrate Faunas

Although early emphasis should be given to the faunas of hard substrate regimes, the faunas of soft substrate areas should be thoroughly studied.

Action - Identify, characterize and quantitatively describe the faunas of various soft substrate biotopes in the canyon head and between 100 and 1000 meters. These investigations should be coordinated with geological characterization of the soft substrate regimes.

3) In situ Experimental Studies

Our understanding of benthic populations and the processes that shape these populations has been markedly advanced in recent years through in situ experimental studies in shallow waters. These experiments involve a wide range of activities such as excluding predators with barriers, caging selected predators over specific sites, disturbing substrate and measuring recolonization rates, and conducting dome studies to determine population or individual species respiration. Comparable studies should be undertaken in Norfolk Canyon on both hard and soft substrate biotopes.

Action - Initiate in situ experiments to investigate ecological processes (e.g. community metabolism, predator pressure, recolonization, succession). These experiments will require use of submersibles or remote-operated vehicles to set and recover experiments.

b. Epipelagic Biological Studies

Only scant information is available concerning the relationship between submarine canyons and pelagic species at the ocean surface. However, the empirical observations of both fishermen and scientists indicate that epipelagic fishes of

commercial and recreational importance often concentrate immediately over the head of Norfolk Canyon. This phenomenon is probably the result of hydrographic processes associated with submarine canyons (Ruzecki, 1979). A plan of epipelagic biological research in the Norfolk Submarine Canyon Sanctuary should initially concentrate on gaining an understanding of the processes responsible for concentration of fishes and other species in the vicinity of the canyon head.

Studies should also focus on determining whether there is a difference between pelagic communities in the region of the Canyon and those in the surrounding continental shelf and whether these can be attributed to canyon processes.

1) Epipelagic Fish Community Studies

A productive course of study without heavy investment would be to examine commercial and sport fishery catch data from the Canyon and shelf region hydrographic, meteorological, and climatological information from the region.

Action - Initiate a study to determine if there are any relationships between commercial and recreational catch data and hydrographic, meteorological or climatological data. This project should be coordianted with the projects on commercial and recreational fisheries of the Canyon.

2) Canyon/Shelf Plankton Studies

Little has been done to establish whether the processes which either form canyons or the processes which arise as a consequence of the presence of canyons result in differences between planktonic biota in the region of canyons when compared to those of adjacent shelf areas relatively uninfluenced by canyon related processes.

Action - Initiate a study to identify and quantify the

planktonic biota (phytoplankton, zooplankton, neuston, etc.) in the region of Norfolk Canyon and compare the canyon plankton community with the community of adjacent shelf areas. This activity should be closely coordinated with hydrographic studies in the region in order to determine what, if any, canyon related processes are impacting the community.

4. Pollution Monitoring

There is not, at this time any evidence of pollution or potential pollution problems in the Norfolk Canyon region. Oil and gas development on the shelf, in areas adjacent to the Canyon, if extensive, could, however, have a potential for degrading the Canyon environment.

There are no data available to establish a baseline of potential contaminants in the canyon sediments. The present levels of organic compounds and metal in Norfolk Canyon sediments should be determined to establish a benchmark against which levels of organics and inorganics determined through periodic monitoring could be evaluated.

Action - Determine the present levels of organic and inorganic compounds present in the sediments of Norfolk Canyon. Design a monitoring program that would have the potential for determining trends in organic and inorganic contaminants entering Canyon sediments.

C. Support Studies

1. Data and Information Management

Studies of Norfolk Canyon and other East Coast submarine canyons have been conducted by a number of federal, state and private institutions (see EG&G, 1983). The data developed from these studies, much of which is in the form of underwater photographs, videotape, or observer notes, has not been

systematically collected and stored in a fashion which would allow all of the available data to be used in development of models or for the testing of hypotheses. The establishment of the Norfolk Canyon Marine Sanctuary will result in increased attention focused on the Norfolk Canyon and a need to enable comparison between Norfolk Canyon and the other East Coast Canyons.

In order to remedy the lack of a central source of information on East Coast Submarine Canyons, three projects are proposed to provide for the orderly storage, retrieval and analysis of information developed in the Norfolk Canyon Marine Sanctuary and to provide the ability to compare the processes between submarine canyons.

a. Information Management Systems Development

This project will develop a system to efficiently process, store and provide access to new and existing data and information developed by studies on Norfolk Canyon and other East Coast Submarine Canyons. The system must allow for storage and retrieval of individual data points, bibliographic information and photographic and videotaped information. The system should provide ready access to investigators and managers, and should have appropriate compatibility with the management information system or network developed for other marine sanctuaries. This system should be designed to meet the information management needs of an Oceanographer Canyon Marine Sanctuary if designated.

Action - Design an information management system to incorporate data, bibliographic material and photographic and videotaped data collected in Norfolk Canyon and other East Coast submarine canyons.

b. Norfolk Canyon Resource Data and Information Base

This will be a continuing project. In the initial phase

existing data, both descriptive (i.e. photos, videotapes, and written or oral descriptions) and numerical, and literature will be located and, where possible, collected at a single site. Where physical custody of the information (or copies) is not possible, descriptions, sufficient enough for referral will be made. This information will be screened and if appropriate accessed to the Information Management System developed under item a (above). As new studies are conducted, data and reports should be added to the Base.

Action - Compile, annotate and store information and data relevant to Norfolk Canyon and other East Coast Canyons. Operate the information management system developed under project a. NOTE: This project and the development of the Information Management System can and should be initiated at the same time).

c. Norfolk Canyon Reference and Study Collection(s)

Because of the depth and topography, relatively few specimens of the major taxa of resident species or geological samples have been collected from the Norfolk Canyon or other East Coast Canyon areas. It is unlikely that the increased attention expected because of Sanctuary designation will greatly increase the number of specimens collected during studies since sanctuary regulations discourage the unnecessary collection of specimens.

This project should locate and document existing collections. Permanent repositories for these collections should be arranged and appropriate descriptions be provided to the Data and Information Base managers for appropriate referral. Agreements for access to existing and future collections for researchers and educators should be obtained. Material suitable for educational displays should be identified.

Action - Locate and catalog existing collections of biological and geological specimens collected from East Coast Submarine Canyons in general and Norfolk Canyon specifically.

Arrange agreements for permanent archiving of these collections either by the present holders of the collections or by an appropriate institution.

Establish agreements for access to these collections for research, teaching and display by appropriate individual or organizations.

2. Socio-Economic Studies

a. Resource Use Studies

Human uses of the Norfolk Canyon and other East Coast Canyon areas have been described in the Environmental Description of Norfolk Submarine Canyon (EG&G, 1983). Principal activities in the Norfolk Canyon area are commercial and recreactional fisheries, military training (primarily naval) and ship transit. There is a potential interest in oil and gas exploration in the Norfolk Canyon, but present practices exclude leasing of areas in the immediate vicinity of canyons.

Commercial fisheries in the immediate vicinity of the Canyon are primarily pot fisheries for red crab and lobster and longlining for swordfish. There may be an increased focus on tilefish as the fishery expands from its southern New England/New York/New Jersey center. The Norfolk Canyon region is regularly fished by recreational and charter vessels. White marlin, yellowfin tuna, and a number of other pelagic species (wahoo, dolphin, skipjack tuna, false albacore and blue marlin) are the target species.

Little or no data exist that can be used to distinguish the importance of the Norfolk Canyon and the processes related

to the Canyon to these fisheries. To remedy this lack of data, specific surveys should be conducted of charter, recreational and commercial fisheries which exploit the resources in the Canyon and adjacent shelf regions. These surveys are some of the few Canyon related studies which can be conducted without expensive and sophisticated logistic and support systems. They could be initiated immediately and continued as one of the means to monitor area productivity.

Three resource use projects are proposed:

1) Commercial Fisheries Utilization of the Norfolk Canyon Area

This project will generate specific data on the commercial fisheries that focus on Norfolk Canyon and the adjacent shelf and slope. Data on catch, effort, and location (depth and coordinates) will be collected. Specific attention will focus on the pot fisheries for crustaceans and the longline fisheries for finfish. Trawl fisheries from shelf areas adjacent to the Canyon will also be described. Economic multipliers should be established to determine the importance of this area.

Action - Initiate a survey of commercial fishermen who harvest resources in and adjacent to Norfolk Canyon. This project should be initiated immediately. It does not require extensive logistic support. It should be a continuing project.

2) Recreational Fisheries Utilization of the Norfolk Canyon Area

This project will generate specific data on the recreational fisheries that take place at Norfolk Canyon and adjacent shelf and slope areas. Data on catch, effort and location will be collected. Information on type of boat

(i.e. charter, head, individual owner, and home port of vessels should also be collected. Allocation of efforts between the Canyon and adjacent areas by various users should be determined. Economic multipliers should be established to distinguish the importance of each area.

Action - Initiate a survey of recreational fishermen frequenting Norfolk Canyon and adjacent shelf/slope areas. This project should be initiated immediately. It does not require extensive logistic support. It should be a continuing project.

3) Other Utilization of The Norfolk Canyon Area

In addition to the fishing activity in the Norfolk Canyon, heavy utilization comes from the military and civilian ships transiting (or in the case of the military - exercising in) this area. The extent of this non-fishery use should be quantified.

Action - Identify and quantify the activities of both the military and civilian sectors which utilize the area in the vicinity of the Norfolk Canyon.

b. Attitudinal Research

Public awareness of the outer continental shelf margin in general and submarine canyons in particular is not great. Because of its depth and distance from the shore, Norfolk Canyon is not readily accessible for visitation. Recreational and commercial fishermen or persons transiting the area cannot obtain a perspective of the processes or structure of the Canyon from the surface. The Interpretation Plan addresses this difficulty and provides approaches to enhance public concern.

The research study plan can assist in the implementation of the Interpretation Plan by focusing a research activity towards delineating attitudes toward submarine canyons and determining

what they would be most interested in learning about canyons in general and Norfolk Canyon in particular.

1) Public Attitudes Towards Norfolk Canyon

Through the use of written and oral surveys, the prevailing public knowledge of Norfolk Canyon should be determined. An attempt should be made to ascertain what people would like to know about canyons, their processes and the relationship between processes and the environment in the Canyon area.

Action - Initiate an attitudinal survey to determine what attitudes persons now have towards submarine canyons (if any) and try to deterime what they would most like to know about canyons.

D. Implementation Strategy

The Resource Study Plan has been developed to provide a comprehensive long-term framework for research and monitoring. The Plan is not static. It should be reviewed periodically and revised when appropriate.

Because of the logistic support required for the majority of the research necessary to understand the processes in Norfolk Canyon, it will be necessary to develop a very specific annual study schedule. The availability of submersibles, remote-operated-vehicles, and oceanographic vessels will determine the extent of studies in any particular year.

It is expected that funding for studies in this plan will come from a variety of sources. It is anticipated that NOAA will obtain submersible and oceanographic ship support for the majority of the Norfolk Canyon studies. The participation of scientists funded by other sources is encouraged. Allocation of vessel and submersible resources will be based upon such criteria as: 1) relevance or importance to sanctuary management; 2) relevance or importance to

understanding of canyon processes; 3) scientific, technical or educational merits; 4) immediacy of need (i.e. is the sanctuary under some threat to its viability); and 5) environmental consequence (i.e. compatibility with sanctuary management goals).

Funding of specific projects by NOAA will be determined in accordance with existing NOAA policy and priorities.

All projects proposed for the sanctuary whether funded by NOAA or other sources will be reviewed by a scientific multidisciplinary peer review group which will recommend priority for logistic support.

The peer review group will also provide an annual recommendation to NOAA on the extent to which the objectives of the Resource Study Plan are being accomplished. This recommendation from the peer group will be used by the Sanctuary Manager to develop recommendations for NOAA funding of sanctuary studies.

A fundamental consideration in the implementation of this research plan is the interdisciplinary nature of the research needed to understand the Norfolk Canyon ecosystem.

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