New England Fishery Management Council
50 WATER STREET | NEWBURYPORT, MASSACHUSETTS 01950 | PHONE 978 465 0492 | FAX 978 465 3116
Thomas R. Hill, *Acting Chairman* | Paul J. Howard, *Executive Director*

HABITAT AREA OF PARTICULAR CONCERN ALTERNATIVES

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2.0 Introduction and Background

The intent of the habitat areas of particular concern designation is to identify those areas that are known to be important to species which are in need of additional levels of protection from adverse impacts. Management implications do result from their identification. Designation of habitat areas of particular concern is intended to determine what areas within EFH should receive more of the Council's and NMFS' attention when providing comments on federal and state actions, and in establishing higher standards to protect and/or restore such habitat. Certain activities should not be located in areas identified as habitat areas of particular concern due to the risk to the habitat. Habitats that are at greater risk to impacts, either individual or cumulative, including impacts from fishing, may be appropriate for this classification. Habitats that are limited in nature or those that provide critical refugia (such as sanctuaries or preserves) may also be appropriate. General concurrences may be granted for activities within habitat areas of particular concern; however, greater scrutiny is necessary prior to approval of the general concurrence.

The EFH Final Rule (50 CFR 600.815(8)) states that *"FMPs should identify specific habitat types or areas within EFH as habitat areas of particular concern based on one or more of the following considerations… (underlined text)".* The corresponding text is a Council interpretation of the EFH Final Rule criteria.

CRITERION 1A: Importance of *Historic* Ecological Function - The area or habitat feature proposed for HAPC designation at one time provided an important ecological function to a currently managed species, but no longer provides that function due to some form of degradation. An important ecological function could include, but is not limited to, protection from predation, increased food supply, appropriate spawning sites, egg beds, etc. The importance of the ecological function should be documented in scientific literature and based on either field studies, laboratory experiments, or a combination of the two.

CRITERION 1B: Importance of *Current* Ecological Function - The area or habitat feature proposed for HAPC designation currently provides an important ecological function to a managed species. An important ecological function could include, but is not limited to, protection from predation, increased food supply, appropriate spawning sites, egg beds, etc. The importance of the ecological function should be documented in scientific literature and based on either field studies, laboratory experiments, or a combination of the two.

CRITERION 2: Sensitivity to Anthropogenic Stresses – The area or habitat feature proposed for HAPC designation is particularly sensitive (either in absolute terms or relative to other areas and/or habitat features used by the target species) to the adverse effects associated with anthropogenic activities. These activities may be fishing or non-fishing related. The stress or activity must be a recognizable or perceived threat to the area of the proposed HAPC.

CRITERION 3: Extent of Current or Future Development Stresses – The area or habitat feature proposed for HAPC designation faces either an existing and on-going development-related threat or a planned or foreseeable development-related threat. Development-related threats may result from, but are not limited to, activities such as sand mining for beach nourishment, gravel mining for construction or other purposes, the filling of wetlands, salt marsh, or tidal pools, shoreline alteration, channel dredging (but not including routine maintenance dredging), dock construction, marina construction, etc.

CRITERION 4: Rarity of the Habitat Type – The habitat feature proposed for HAPC designation is considered "rare" either at the scale of the New England region or at the scale of the range of at least one life history stage of one or more Council-managed species. A "rare" habitat feature is that which is considered to occur infrequently, is uncommon, unusual, or highly valued owing to its uniqueness. Keep in mind that the term "rare" usually implies unusual quality and value enhanced by permanent infrequency. We may usually think of rare habitats or features as those that are spatially or temporally very limited in extent, but it could also be applied to a unique combination of common features that occur only in a very few places.

The Council encouraged the development of HAPC proposals that (in no particular order):

- Will improve the fisheries management in the EEZ.
- Include EFH designations for more than one Council-managed species in order to maximize the benefit of the designations.
- Include juvenile cod EFH.
- Meet more than one of the EFH Final Rule HAPC criteria.

A Request for Proposals soliciting ideas from the public on Habitat Areas of Particular Concern, for consideration in the EFH Omnibus Amendment #2, was issued on December 18, 2004 and closed on March 25, 2005 during which time the public was freely able to prepare and submit candidate HAPC proposals for the Council's consideration. Nine (9) complete proposals were received by the Council. The Council has reviewed these proposals through their Habitat Plan Development Team, Habitat Advisory Panel and Habitat Oversight Committee and developed *management alternatives* for Council consideration.

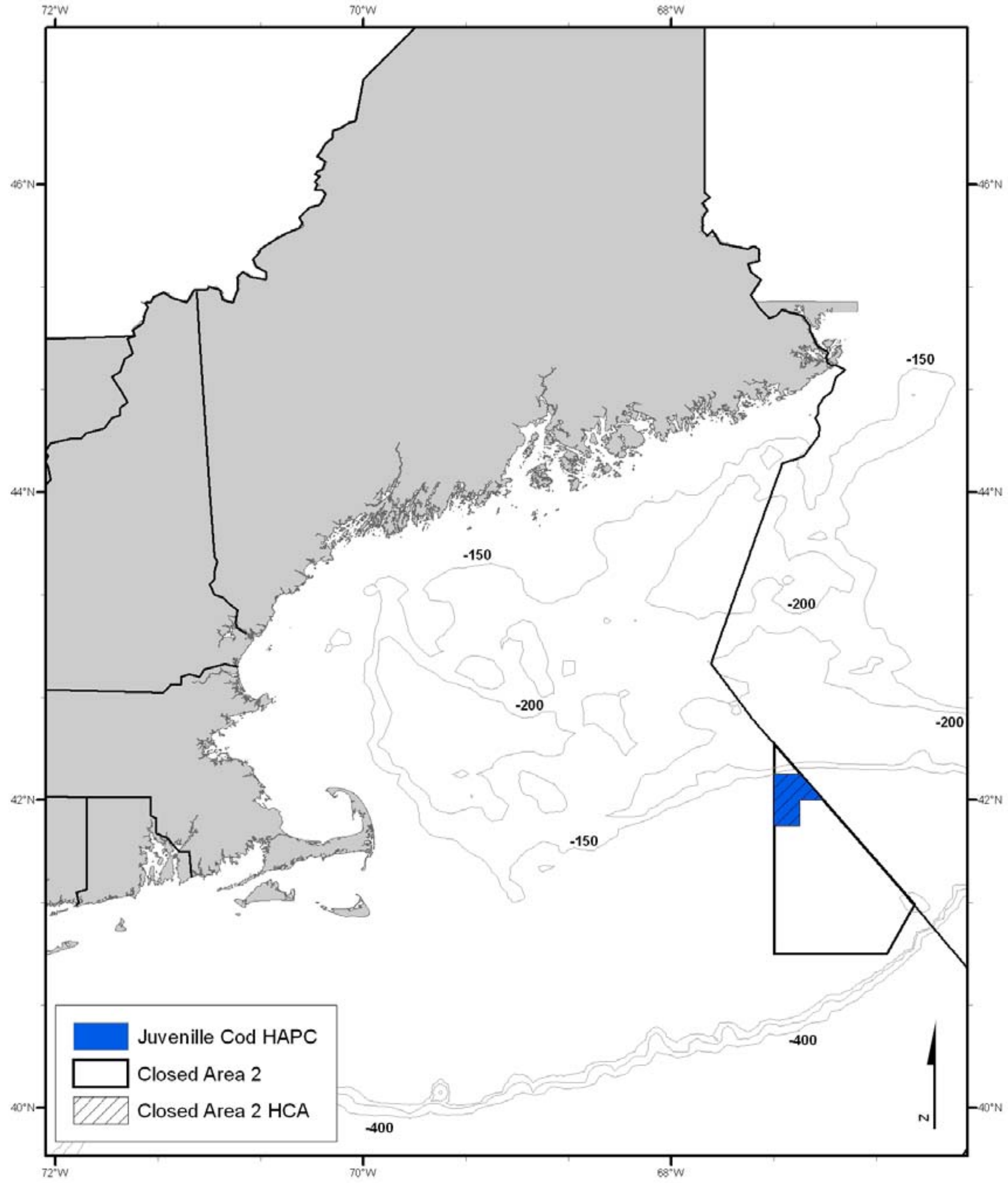
3.0 Alternatives for Habitat Areas of Particular Concern

3.1.1 Alternative 1: Status Quo

Following a review of the scientific literature for information on areas deserving special attention or species with particular habitat associations, the Council designated an area on Georges Bank as an HAPC for juvenile Atlantic cod (Map 1) and eleven rivers in Maine as HAPC for Atlantic salmon (Map 2) in 1998.

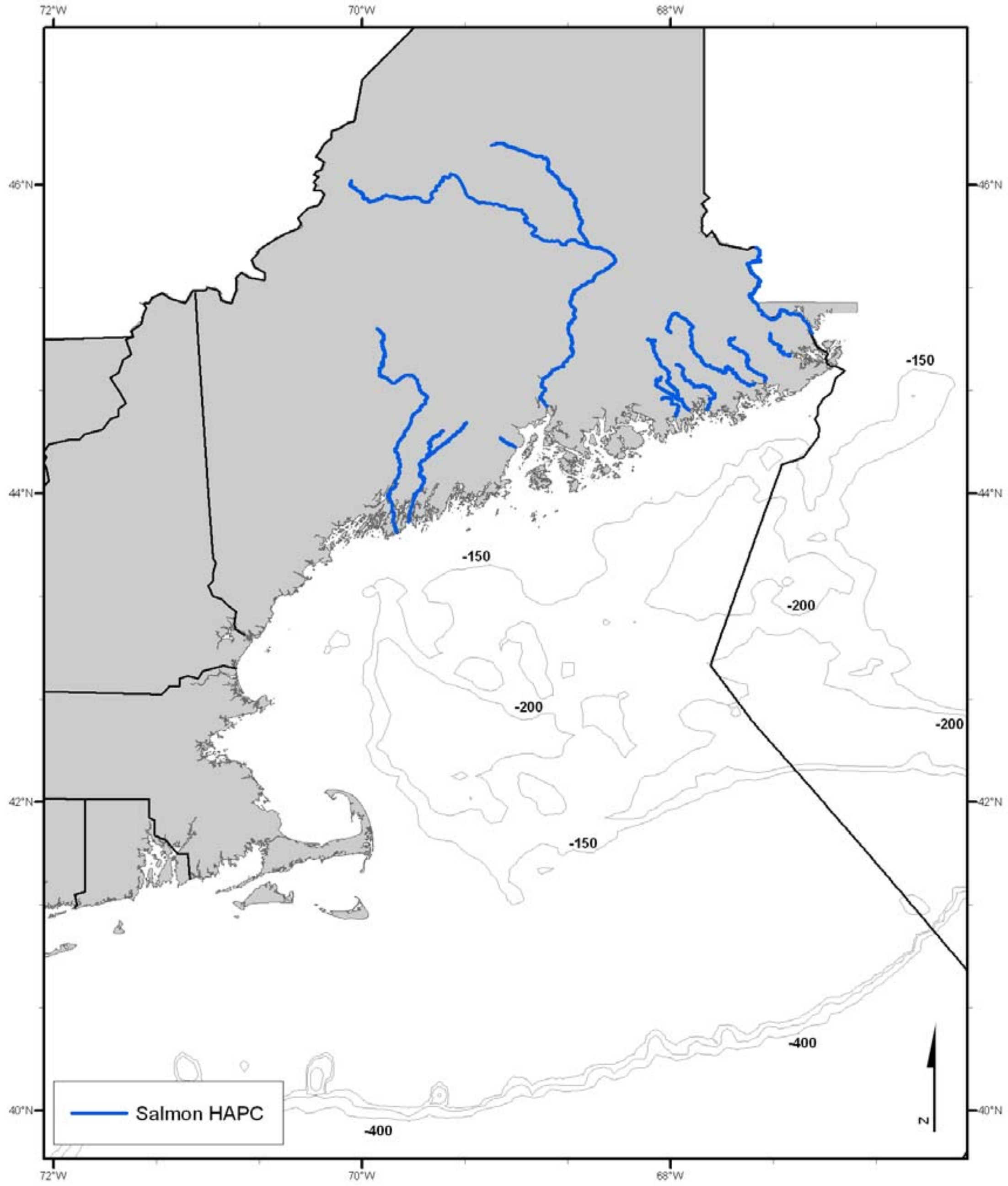
3.1.1.1 Alternative 1A: Cod Status Quo HAPC

Map 1. Alternative 1A: Cod Status Quo HAPC



3.1.1.2 Alternative 1B: Atlantic Salmon Status Quo HAPC

Map 2. Alternative 1B: Atlantic Salmon Status Quo HAPC



3.1.2 Alternative 2: Seamounts

Overview:
Alternative 2 seeks to designate seamounts within the New England Seamount chain inside the U.S. EEZ with the goal of benefiting habitat by recognizing the seamounts physical structure and ecological function. Seamounts support ecological communities with a high level of biodiversity that includes deep-sea corals and a wide array of ocean species that rely on them. The seamount habitats, which contain structure-forming organisms such as deep-sea corals, are extremely sensitive to disturbance and likely have recovery periods on the order of centuries. While these seamounts are not currently fished, this is an important and limited opportunity to protect this habitat before it is disturbed and is a pre-cautionary alternative worth public input.

This alternative includes two options:

Option A: Bear and Retriever where managed species (deep-sea red crab) have been documented (Map 3)

Option B: Bear, Retriever and Physalia seamounts where managed species have been documented or can be inferred to exist by analogy (Map 4).

While these seamounts are further offshore than the shelf edge and slope, and are not within areas traditionally managed by current Fishery Management Plans (FMPs), they are within the EEZ and deep-sea red crab have been document in these areas and EFH for red crab is for these seamounts is under consideration.

An HAPC designation is proposed for Bear, Physalia and Retriever seamounts, and the minor topographic rises surrounding them, that are within the U.S. EEZ off the southern edge of Georges Bank. The HAPC is proposed to elevate recognition for the occurrence of habitat-forming organisms such as deepwater corals and co-occurring species (e.g., sponges) that are abundant within seamount landscapes. Corals are extremely sensitive to disturbance and, with low recruitment and growth rates, require extremely long periods of time to recover from any damage. In summary, designation of these areas as HAPC is an opportunity to recognize sensitive coral communities with no impact to current economic investments by the fishing industry.

Supporting Research
Seamounts have steep and complex topography, impinging currents with topographically induced upwellings, wide depth ranges, are dominated by hard substrates, are geographically isolated from continental platforms, and are dominated by invertebrate suspension feeders. Seamount faunas generally exhibit a high degree of endemism, owing to their isolation as well as the high degree of landscape variation at

small and large spatial scales. The New England Seamount chain is a line of extinct volcanoes running from the southern side of Georges Bank to a point midway across the western Atlantic. The New England Seamount Chain, the Corner Rise Seamounts, the mid-Atlantic Ridge, and the deep sides of the Azores constitute a nearly continuous series of hard substrate "islands" in a sea of abyssal mud extending across the North Atlantic Ocean. These islands are therefore rare habitats within the context of the whole North Atlantic basin. The most westerly seamounts (i.e., Bear, Physalia, Retriever, and Mytilus) are within the boundary of the United States Exclusive Economic Zone. Several of the seamounts were visited by geologists in 1974, but there has been little biological exploration of the area. Our group (the Mountains-in-the-Sea Research Group) has conducted some of the first ecological studies along the New England Seamount Chain.

It is known, from preliminary work conducted along the western side of the North Atlantic, and by German scientists in the eastern Atlantic, that some species of deep-sea octocorals and fish can be found in both areas. The Watling and Auster (2005) collections also indicate that there is a biogeographic separation of the eastern and western basins faunas, each with their own endemic species. This suggests that individual seamounts, or small groups of seamounts, may also harbor endemic species. In 2003 we collected 63 coral specimens at Bear, Kelvin, and Manning seamounts using the submersible *Alvin*. This collection contained 15 octocoral genera, 6 antipatharian genera, and some unknown number of zoanthid genera. With an increased number of dives in 2004 using the ROV *Hercules*, 135 corals were collected at Bear, Retriever, Balanus, Kelvin, and Manning seamounts. These specimens represent 23 octocoral genera, 7 antipatharian genera, and an unknown number of zoanthid genera. In all, 14 genera were added in 2004, including at those seamounts visited in 2003. From the videotapes it has also been noted other octocoral colonies that so far remain uncollected. There are a series of taxonomic problems in several of the genera, so no estimate of species can be made at this time. However, an initial inspection of the material collected suggests the occurrence of about 15 new species, most in the families Plexauridae, Chrysogorgiidae, and Primnoidae. Taxonomic, genetic, and reproductive studies are ongoing. However, given the greater degree of investigation of corals in the east Atlantic, the presence of these undescribed species also suggests that they have very limited distributions.

Watling and Auster have also used video transects to census deep sea fishes and characterize the landscape in which they operate. To date, they have observed 36 fish taxa from 24 families based on *Alvin*, *Hercules* and *ABE* imagery. Moore et al. (2003a) listed 591 species of deepwater fishes in the northwest Atlantic Ocean that occur at depths greater than 200 m. However, the zoogeography of this region as whole has not been resolved to the level that can predict patterns of distribution and diversity at medium to small spatial scales (i.e., the spatial scale within and between seamounts across the region). Based on observations of variations in habitat features within seamount landscapes, and general patterns in the associations of fishes with such features, we developed a hierarchical landscape classification scheme to classify patterns of habitat use in deepwater fishes (Auster et al. 2005). The classification scheme includes geological and biological features as well as the local flow regime as habitat attributes. Preliminary analysis suggests that seamount fishes can be divided into four groups. The members of the first group are generalists and occur in all habitat types. These include halosaurids (i.e. *Aldrovandia* spp.), macrourids (i.e., *Caelorinchus* spp., *Nezumia* spp.), and *Synaphobranchus kaupi*. The second group, which occurs primarily in basalt habitats, includes an oreosomatid (*Neocyttus helgae*) that appears to have an association with both corals and depressions within basalt pavements. Taxa that make up the third group occur in fine-grained sediment habitats, including macrourids (*Coryphaenoides* spp.), chimaerids (*Hydrolagus* spp.), rajids, alepocephalids, ipnopids (*Bathypterois* spp.), and synodontids (*Bathysaurus* spp.). One final group appears to be specialized in living along the ecotone of ledges and sediment and includes morids (*Antimora rostrata* and *Laemonema* spp.), ophidiid cusk-eels and other synaphobranchids besides *S. kaupi*. Analysis of transect data is ongoing.

The observed size structures of coral colonies are intriguing. Prior anecdotal observations have indicated that stands of deep-water octocorals tend to be relatively uniform in size, and conspicuously lacking in small colonies. This general pattern is being found in two species *Paragorgia* sp. and *Lepidisis* sp., but in *Paragorgia* tiny recruits have been discovered, consisting of just a few polyps. For this species, it may be that post-settlement mortality plays a role in the absence of small colonies. The size distributions of corals will become much more informative when we can convert them to age distributions. Studies to develop this size-age relationship are underway but regardless of the outcome, it appears that in general, coral communities are composed of cohorts from highly sporadic recruitment.

The authors are in the process of quantifying distributions of several species (*Paragorgia* sp. *Lepidisis* spp. *Metallogorgia* sp., *Paramuricea* spp., *Candidella* sp., *and Corallium* sp., as well as other scleractinians and antipatharians) using videotapes and digital still images. Preliminary quantitative analyses of coral species distributions indicate that community composition differs considerably between seamounts, even at comparable depths. These differences correspond to biogeographical boundaries, or they may be due to species' responses to local habitat conditions, such as substratum type or flow. Substantial variation in faunal composition occurs between sites on a single seamount.

Merrett (1994) found that species richness of deepwater fishes in the North Atlantic, at depths greater than 250 m, was approximately 1094 species belonging to 143 families (589 pelagic and 505 demersal). That there are boundaries limiting the distribution of many species in this vagile fauna is evidenced by the reduced number of taxa (591) found in the northwest Atlantic alone (Moore et al. 2003a). Further, given that most ichthyofaunal surveys beyond continental shelf waters have been conducted using various types of towed nets over widely separated sampling stations, understanding the actual distribution of many deepwater taxa remains elusive. For example, trawl sampling by Moore et al. (2003b) at Bear Seamount revealed two species known previously only from the eastern Atlantic (i.e., *Hydrolagus pallida* and *Bathypterois dubius*). Watling and Auster have observed *H. pallida* on Manning Seamount as well, using the *Hercules* ROV in 2004. Observations of false boarfish, *Neocyttus helgae*, nominally an eastern Atlantic species, were also made during video transects at multiple seamounts during both 2003 and 2004 expeditions (Moore et al in prep.). These observations suggest that seamount chains may provide "stepping stones" for dispersal and maintenance of populations of deepwater demersal fishes across ocean basins where their vertical distributions are restricted to slope depths (sensu Moore et al. 2003b). These observations are consistent with those of Kukuev (2002) who showed that there was little differentiation in the deepwater fishes (>500 m) of the Corner Rise Seamounts, mid-Atlantic Ridge, and east Atlantic seamounts. However, the shallow water ichthyofauna (from those peaks with depths <300m) east of the mid-Atlantic Ridge showed affinities for east Atlantic shelf faunas.

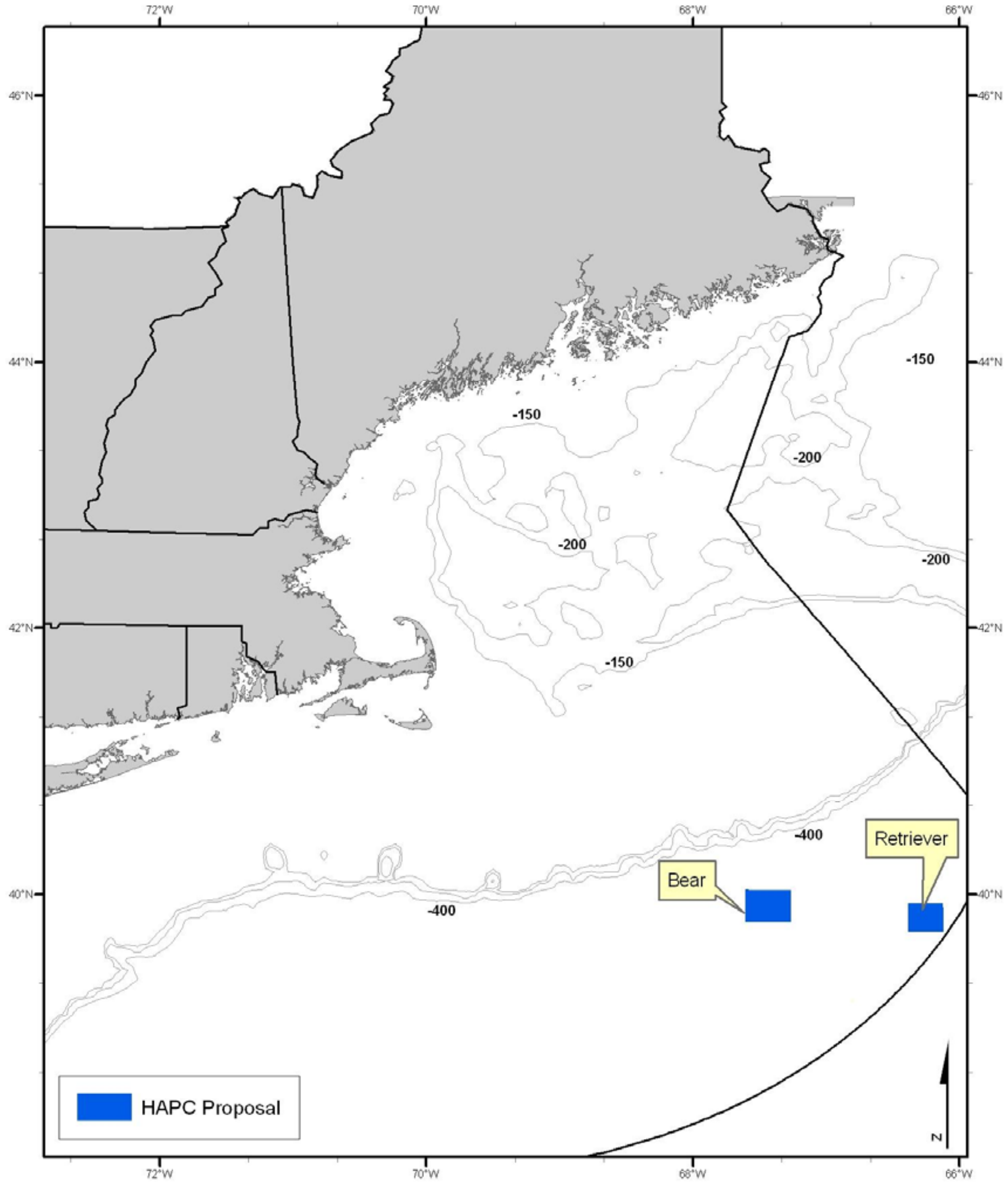
The available evidence from both octocorals and fish distributions suggests that the fauna of the New England Seamount chain is a part of a broad North Atlantic fauna with a regional endemism component (Watling and Auster, 2005). Since the chain of seamounts is nearly continuous from Bear Seamount to the Azores, a transition to an eastern Atlantic fauna must occur somewhere along the chain of seamounts, either at the Corner Rise seamounts or in the vicinity of the mid-Atlantic ridge. From Reid's (1994) analysis of flow at 2000 m, it would appear that the Corner Rise seamounts, and perhaps the easternmost New England chain seamounts such as Nashville, receive flow directly from the east and so should look more like the deep Azorean fauna than do the seamounts at the western end of the New England chain. Still, there are difficulties with this interpretation. Reid's (1994) flow analysis suggests a general east to west deep flow across the Atlantic south of 30° N with no northeastward flow south of the Gulf Stream. However, several of the octocorals that we have been able to identify so far were originally described from the deep Antilles and Florida Straits and others have been found on the Reykjanes Ridge (Keller and Pasternak 2001). These species have so far not been identified from the eastern Atlantic, suggesting that they are western Atlantic endemics with a larval connection between the New England seamounts and the deep Antilles. On the other hand, there seems to be a slight correspondence between the Antillean deep octocoral fauna and that from eastern mid-latitude seamounts, such as Great Meteor and the deep sides of the Azores (Grasshoff 1977, 1981). The results of the work by Watling and Auster suggest a degree of endemism in seamount fauna that warrants considering a risk-averse approach at the only seamounts in the Atlantic EEZ of the United States.

Corals are clearly sensitive to fishing gear impacts and recovery rates are extremely slow based on our knowledge of recruitment, growth rates, and age structure. The ability to age deep-water scleractinians and octocorals is relatively new and different methods are used in different studies. For *Primnoa resedaeformis*, a common outer shelf-upper slope species, Risk et al. (2002) estimates linear growth rates at the distal tips of the colonies at 1.5-2.5 mm yr-1 based on comparisons of live specimens with growth rates through the base of a sub-fossil specimen collected from the Northeast Channel at 450 m. Growth rates of this same species in the Gulf of Alaska are reported as 1.60-2.32 cm yr-1 , although these samples were collected at less than 200 m depth (Andrews et al. 2002). Age estimates for only a few specimens demonstrate this species lives for hundreds of years. The colony collected from the Northeast Channel (Risk et al. 2002) has an estimated age of >300 years, which is in accordance with age estimates of the same species collected in Alaska (>100 years; Andrews et al. 2002). *Desmophyllum cristagalli*, a deep-water scleractinian, grows at 0.5-1.0 mm yr-1 and lives >200 years, with this growth rate verified by a specimen collected from an aircraft sunk in Baltimore Canyon in 1944 (Lazier et al. 1999; Risk et al. 2002). A 1.5 m high colony of the deep-water scleractinian coral *Lophelia pertusa* may be up to 366 years of age (Breeze et al. 1997). Deep-water reefs of *Oculina varicosa* form pinnacles and ridges 3-35 m in height off the east coast of Florida and have an average growth rate of 16.1 mm yr-1 (Reed 2002). Based simply on age and growth information, recovery of impacted colonies and thickets may take hundreds of years.

Data on recruitment patterns are even more limited. A single series of observations in the Gulf of Alaska suggest that recruitment of *Primnoa* sp. is patchy and aperiodic (Krieger 2001). No recruitment of new colonies was observed in an area where *Primnoa* was removed by trawling after seven years. However, six new colonies were observed at a second site one year after trawling. Four of these colonies were attached to the bases of colonies removed by trawling. Recruits of *Primnoa* were also observed on two 7 cm diameter cables (>15 colonies each). Limited observations of corals in the Gulf of Maine and in submarine canyons have not revealed widespread coral recruits (Watling, Auster, and France, unpublished observations). The Seamount HAPC alternatives should be considered as a precautionary management measure to preclude impacts to a highly sensitive fauna (Auster 2001).

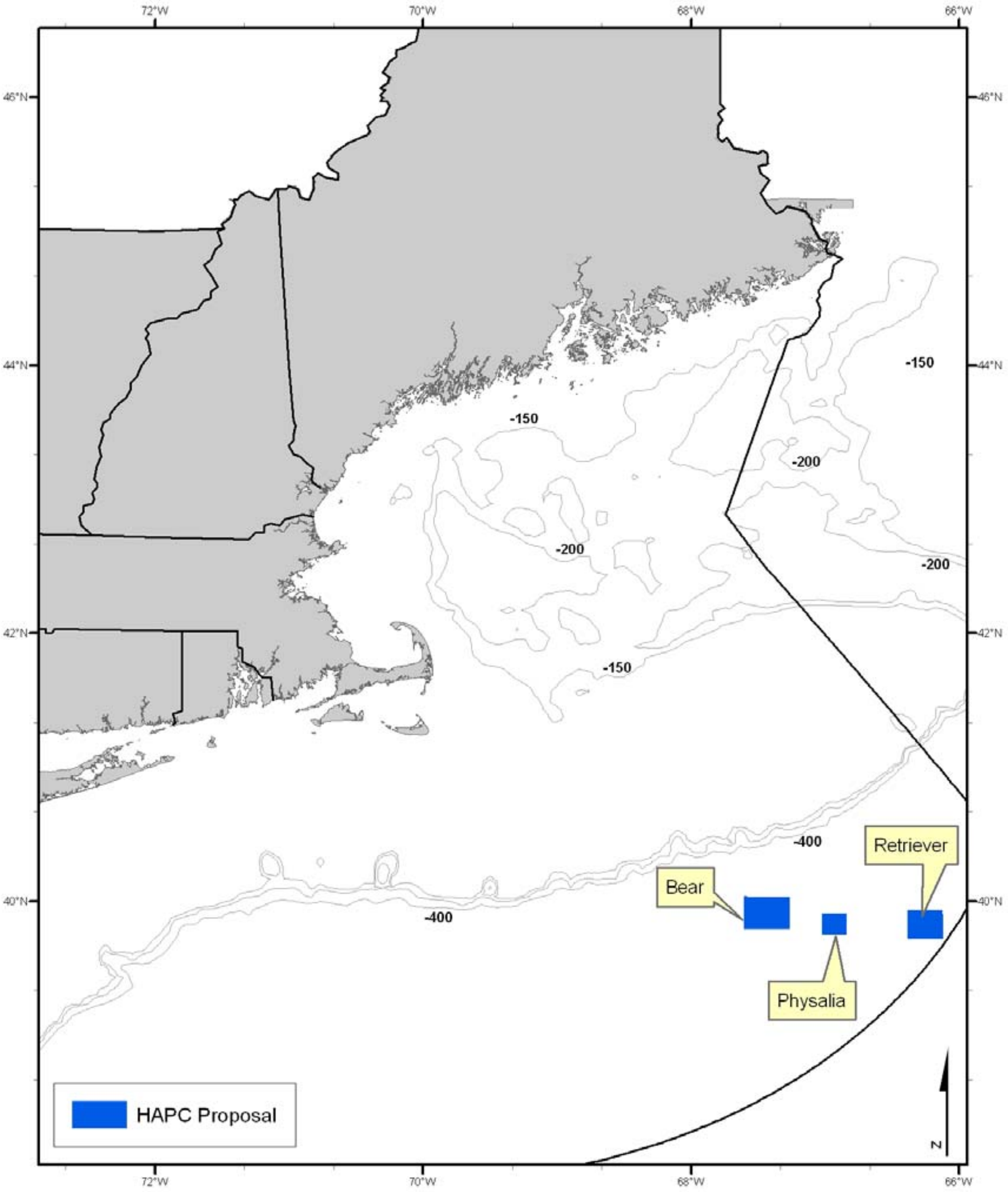
3.1.2.1 Alternative 2A: Bear and Retriever Seamounts

Map 3. Seamount Alternative 2A (Bear and Retriever Seamounts)



3.1.2.2 Alternative 2B: Bear, Retriever and Physalia Seamounts

Map 4. Seamount Alternative 2B (Bear, Retriever and Physalia)



3.1.3 Alternative 3: Deep-Sea Canyons

Overview
This alternative (**M**ap 7 - Map 21) is intended to identify canyon habitats that contain, or are believed to contain, structure-forming organisms (e.g. deep-sea coral species) and, in doing so, to recognize the benthic communities and marine ecosystems of which they are a part. Recognizing the importance of these species and their communities will be a first step towards maintaining the vital functions they provide for managed fish species, of which there is some evidence but also a clear need for further research.

Although the Alternatives (3A – 3O) are housed under one main umbrella of "Deep-Sea Canyons", each canyon(s) alternative will be treated individually.

3A: Heezen
3B: Lydonia
3C: Gilbert
3D: Oceanographer
3E: Hydrographer
3F: Veatch
3G: Alvin and Atlantis
3H: Hudson
3I: Toms and Hendrickson
3J: Wilmington
3K: Baltimore
3L: Washington
3M: Norfolk
3N: Oceanographer, Gilbert and Lydonia
3O: Toms, Hendrickson and Inter-Canyon Areas

The main purpose of the individual canyon HAPC alternatives is to designate as HAPC deep-sea canyons in the northeastern U.S. that contain or are believed to contain habitat-forming organisms including, but not limited to, stone corals (Cnidaria, Anthozoa, Hexacorallia, Sceractinia), black corals (Anthipitharians), cerianthid anemones (Cnidaria, Anthozoa, Hexacorallia, Ceriantharia), soft corals (Cnidaria, Anthozoa, Octocorallia), sea pens (Cnidaria, Anthozoa, Octocorallia, Pennatulacea) and sponges (porifera).

Structure- or Habitat-Forming Organisms
With respect to fisheries management and habitat protection, at least eight invertebrate groups contain species that potentially provide structures that form habitats for other marine organisms in deep water off the northeast coast of the United States.

Numerous specimens of structure-forming animal groups (mainly cnidarians and sponges) collected in deep water (>100m) off the northeast coast of the United States (37º-42ºN and 66º-75ºW) are housed in the Smithsonian's National Museum of Natural History. These specimens were obtained from a variety of sources from the late 1800's to the present. The vast majority was collect for two government entities, the Bureau of Land Management's Minerals Management Service (BLM/MMS) and the National Marine Fisheries Service (NMFS) and its predecessor the U. S. Fish Commission (USFC). Roughly one third of the specimens were obtained for BLM/MMS by various organizations (including Woods Hole Oceanographic Institute, the University of New England Marine Laboratory, and the Virginia Institute of Marine Science) and individuals. Collection data on the specimens directly indicate that 391 specimens were collected for NMFS/USFC. An additional 716 specimens can be inferred to have been collected for the USFC because the vessels (Albatross R/V and Fish Hawk R/V) used to make the collections were operated by USFC. Thus, nearly two thirds of the collections were obtained for NMFS/USFC. Only 660 of the specimens have the gear used to obtain them noted in their collection data. The majority of specimens were obtained using some form of trawl. Dredges, grabs, box corers, and bottom skimmers were also used to collect some of the specimens present in the Smithsonian collections.

Group 1: Antipatharia (Cnidaria, Anthozoa, Hexacorallia) – Black Corals
Antipatharians are colonial cnidarians. Colonies, which usually have a branching form, are held erect by a rigid skeleton composed of proteins with a horny consistency. Colonies grow on hard substrates and range from 10 to well over 100 cm in height. Antipatharians are predominantly tropical, but species are known to occur in the area of interest. Genera documented in Smithsonian Collections: *Leiopathes*

Group 2: Ceriantharia (Cnidaria, Anthozoa, Hexacorallia) – Tube Anemones

Cerianthariansive within self-constructed tubes. These tubes have a rubbery consistency and are formed by mucus and sediment grains held together by discharged nematocysts (typically the stinging cells of cnidarians). Ceriantharians are solitary animals that inhabit soft substrates. Usually their tubes, which can be up to one meter in length, are entirely below the sediment-water interface. In some species tubes may extend above the seafloor by up to 20 cm. Genera documented in Smithsonian Collections: *Cerianthiopsis* and *Cerianthus.*

Group 3: Other Anemones (Cnidaria, Anthozoa, Hexacorallia) including Actiniaria, Corallimorpharia, and Zoanthidea – Anemones Other Than Tube Anemones

Anemones are solitary hexacorals that lack mineralized skeletons. They are barrel shaped animals that primarily live attached to hard substrates. They are not commonly thought of as "structure forming" organisms. Nevertheless, they range in size from less than one cm to tens of centimeters in height and therefore potentially add to environmental complexity where they occur. Note however that many species are gregarious and may form mats. Numerous species, particularly of Actiniaria, have been documented in the area of interest. Genera documented in Smithsonian Collections: *Actinauge, Actinernus, Actinostola, Actinothoe, Adamsia, Antholoba, Bolocera, Dactylactis, Edwardsia, Halcampa, Hormathia, Metridium, Paracalliactis, Paraedwardsia, Peachia, Raphactis, Sagartia, Sagartiogeton, Stephanauge, Tealia, Urticina, Corynactis, and Epizoanthus.*

<u>Group 4</u>: Scleractinia (Cnidaria, Anthozoa, Hexacorallia) – Stony Corals

Scleractinians can be either solitary or colonial. While a majority of species live with their aragonitic skeletons firmly attached to hard substrate, roughly one third live unattached on soft sediments. The size range of scleractinians is great. Some of the solitary unattached species measure just a few mm across, whereas colonial species can make structures with dimensions measured in meters. Genera documented in Smithsonian Collections: *Caryophyllia, Dasmosmilia, Desmophyllum, Enallopsammia, Flabellum, Fungiacyathus, Javania, Lophelia, Solenosmilia and Vaughanella.*

<u>Group 5</u>: Pennatulacea (Cnidaria, Anthozoa, Octocorallia) – Sea Pens

Pennatulaceans are colonial octocorals that live in soft sediment habitats. They possess a large, primary axial polyp, which is differentiated into a bulbous region that anchors the colony in soft substrate, and a distal region from which secondary polyps arise. Sea pens do not have branching forms but instead have shapes that are elongate. They range in size from roughly 1 cm to well over 1 meter in height. Genera documented in Smithsonian Collections: *Anthoptilum, Balticina, Benthoptilum, Distichoptilum, Funiculina, Kophobelemnon, Pennatula, Renilla, Scleroptilum, Stylatula, Umbellula and Virgularia.*

<u>Group 6</u>: Other Octocorallia (Cnidaria, Anthozoa, Octocorallia) including species formerly classified as Gorgonacea and Alcyonacea – Soft Corals, Sea Fans, Sea Whips

Octocorals other than pennatulaceans are a heterogenous group of anthozoan cnidarians. Nearly all are colonial organisms. The group is predominantly associated with hard substrate but a small number of species are adapted to life in soft sediments. Adults range in size from around 10 cm to well over one meter. Many forms are branching. The gorgonians, or sea fans, possess a rigid scleroproteinaceous axis and form the most complex structures. Genera documented in Smithsonian Collections:

Acanella, Acanthogorgia, Anthothela, Chrysogorgia, Keratoisis, Lepidisis, Lepidogorgia, Paragorgia, Paramuricea, Primnoa, Radicipes, Swiftia, Anthomastus, Duva and Gersemia.

<u>Group 7</u>: Porifera -- Sponges
Poriferans are diverse in form, varying from encrusting to ball-shaped, vase-shaped, and fan-shaped. Some forms branch or even anastomose, others are stalked. Some sponges have calcareous skeletons (composed of spicules), but most have siliceous skeletons. The siliceous spicules of some sponges in the group Hexactinellida (glass sponges) have fused spicules providing a rigid structure. Sizes range from minute to in excess of one meter. Poriferans can be found on both hard and soft substrates, but hard substrates appear to be favored by a majority of species. Genera documented in Smithsonian Collections: *Asbestopluma, Asconema, Axinella, Chondrocladia, Cliona, Gelliodes, Halichondria, Isodictya, Leucoselenia, Microciona, Reniera, Stylocordyla, Suberites, Sycon, Sympagella, Tethya and Trichostemma.*

<u>Group 8</u>: Crinoidea (Echinodermata) – Sea Lilies, Feather Stars
Crinoids known as sea lilies have a stalk, on top of which sits a calyx supporting numerous branched arms. Other crinoids, the feather stars, lack a stalk and thus do not extend very far off the sediment-water interface. Both types of crinoids are usually encountered on hard substrate, with the latter group frequently using a set of cirri to attach themselves (and move around upon) other structure forming organisms. Genera documented in Smithsonian Collections: *Antedon, Hathrometra and Rhizocrinus.*

<u>Group 9:</u> Sabellidae and Sabellerriidae (Annelida, Polychaeta, Canalipalpata) – Tubeworms, Fanworms, or Feather Duster Worms
Sabellid and Sabellerriid worms are worms that have a limited ability to creep or move along the substratum. With primarily to exclusively sessile life styles, they inhabit tubes constructed of mucus and sometimes tougher but not mineralized material. They are filter feeders, gathering suitable food with a tentacular crown that spreads out above their mouths. Most species are infaunal and small (just a few mm in length), but some can be as large 15-20 cm in height. Genera documented in Smithsonian Collections: <u>*Chone, Dedemona, Euchone, Jasmineira, Megalomma, Myxicola, Oriopsis and Potamilla.*</u>

Additional Data
In addition to the Smithsonian Collections, the Council has used the Watling and Auster (2005) "Distribution of deepwater alcyonacea off the northeast coast of the United States" database in the development of these alternatives. According to the authors, "a database of deep water alcyonacean records has been assembled using information that

reaches back to the work of A.E. Verrill from the 1800s. These database records fall into two time periods, those from 1874 to 1920, and from 1950 to 2001. A total of 25 species in 10 families are so far known from the northeastern U.S. Most of these species are common in deeper waters of the continental shelf, with a few being restricted to the canyons and other slope environments."

Continental Slope off Northeastern United States

The continental slope extends from the continental shelf break (at depths between 60 m and 200 m) eastward to a depth of 2000 m. The width of the slope varies from 10-50 km, with an average gradient of 3-6°; however, local gradients can be nearly vertical. The base of the slope, where the continental rise begins, is defined by a marked decrease in seafloor gradient.

The morphology of the present continental slope appears largely to be a result of sedimentary processes that occurred during the Pleistocene, including:
1) slope upbuilding and progradation by deltaic sedimentation principally during sea-level low-stands; 2) canyon-cutting by sediment mass movements during and following sea-level lowstands; 3) sediment slumping. The continental slope is cut by more than 20 large canyons between Georges Bank and Cape Hatteras and numerous smaller canyons and gullies, many of which may feed into the larger canyon systems. The New England Seamount Chain including Bear, Mytilus, Balanus, and others occurs on the slope southwest of Georges Bank. A smaller seamount chain (Caryn, Knauss, and others) occurs nearby in deeper water.

Occasional boulders occur on the slope as a result of glacial rafting, and coarse sediments and rock outcrops are found locally on and near canyon walls. Sand deposits may also be formed as a result of downslope movements. A "mud line" occurs on the slope at a depth of 250 m – 300 m, below which fine silt and claysize particles predominate over sand. Gravity-induced downslope movement is the dominant sedimentary process on the slope, and includes slumps, slides, debris flows, and turbidity currents, which range from thick cohesive movement to relatively non-viscous flow. Slumps are localized blocks of sediment that may involve short downslope movement. However, turbidity currents can transport sediments thousands of kilometers.

The water masses of the Atlantic continental slope and rise are essentially the same as those of the North American Basin (Wright and Worthington 1970). Worthington (1976) divided the water column of the slope into three vertical layers: deep water (colder than 4°C), the thermocline (4°-17°C), and warm water (warmer than 17°C). In the North American Basin, the deep water accounts for two-thirds of all the water, the thermocline for about one quarter, and the warm water the remainder. In the slope water north of

Cape Hatteras, the only warm water occurs in the Gulf Stream and in seasonally influenced summer waters.

Submarine Canyons off Northeastern United States

Submarine canyons are not spaced evenly along the slope, but tend to decrease in areas of increasing slope gradient. Canyons are typically V-shaped in cross section and often have steep walls and outcroppings of bedrock and clay. Some canyons extend to the base of the slope, but others continue as channels onto the continental rise. Larger and more deeply incised canyons are generally significantly older than smaller ones, and there is also evidence that some older canyons have experienced several episodes of filling and re-excavation. Many, if not all, submarine canyons may first form by mass-wasting processes on the continental slope, although there is evidence that some canyons formed as a result of fluvial drainage (eg, Hudson Canyon). Canyons can alter the physical processes in the surrounding slope waters. Fluctuations in the velocities of the surface and internal tides can be large near the heads of the canyons, leading to enhanced mixing and sediment transport in the area. Shepard et al. (1979) concluded that the strong turbidity currents initiated in some canyons were responsible for enough sediment erosion and transport to maintain and modify those canyons. As surface and internal tides are ubiquitous over the continental shelf and slope, it can be anticipated that these fluctuations are important for sedimentation processes in other canyons as well. In Lydonia Canyon, Butman et al. (1982) found that the dominant source of low-frequency current variability was related to passage of Gulf Stream warm core rings rather than the atmospheric events that predominate on the shelf.

Georges Bank Canyons

The continental slope that lies seaward of Georges Bank descends with a gradient of 6-7° from the shelf's edge at a depth of 120-160 m to the continental rise at a depth of about 2,000 m. The slope is incised as much as 1 km by submarine canyons and gullies, resulting in the exposure of pre-Quaternary strata. Submarine canyons have been described as V-shaped, sinuous valleys on the continental shelf or slope that resemble land canyons of fluvial origin; the resemblance is in size and in such features as tributaries, steep walls, and exposed ancient rocks (Shepard 1973). This description fits the canyons along the southern edge of Georges Bank quite well. There are at least 15 canyons cut in to the outer shelf and slope from Veatch Canyon in the west to Corsair Canyon in the east. The heads of these canyons are found well offshore (150 km or so) near the continental shelf edge and contrasts with conditions along the narrow California shelf, where canyon heads are close inshore.

Studies from *Alvin* (Ryan et al. 1978) show that tidal currents flowing up and down the canyons keep the canyons free of sediment. However, the presence of pits, mounds, and trails formed by benthic animals indicates, that these currents do not rework the sediment during each tidal cycle. According to Ryan et al. (1978), slumping and sliding of the unconsolidated sediment are also important in maintaining the canyons. Where this sediment has been disturbed, the underlying strata are eroded by the displaced sediment moving across them. Animal activity appears also to be significant in controlling the canyon's morphology. Such activity tends to stir up material, which often can be transported down canyon by tidal currents; it also weakens the strata and leads to slumping.

The canyons may be regarded as highly modified areas of the continental slope that exhibit to varying degrees a more diverse fauna, topography, and hydrography than the intervening slope areas. Alternating erosional and depositional episodes over geologic time have shaped and modified the canyon systems into specialized habitats distinct from the classically defined slope province.

Diverse sedimentary environments are to be found in each canyon; these result from interaction of modern processes with glacial sediments of Quaternary age and with older, stratified rocks exposed in the canyon walls.

Oceanographer Canyon- An Example

The largest, and most studied Georges Bank canyon is Oceanographer Canyon, and it's surficial geology is generally similar to that in the other major canyons. The canyons present a spectrum of habitat types to the megabenthic and epibenthic fauna (crabs, lobster, shrimp, flounders, hake, tilefish, among others), and these habitats closely influence community structure. It is largely the diversity in substrate types that makes canyons richer biologically than the adjacent shelf and slope. This effect of substrate diversity may be aided by an abundance of nutrients introduced by the relatively strong currents in the canyons (Hecker, Blechschmidt, and Gibson, 1980).

The processes responsible for the present distribution of surficial sediments in and around Oceanographer Canyon may be summarized as follows: 1) as sea level fell, Wisconsinan glaciers advanced onto the Canadian Shelf and the northern margin of Georges Bank; 2) sand and gravel were deposited near the ice front in fluvial and nearshore marine environments; sandy silt containing cold water marine faunas was deposited farther offshore, mantling the outer shelf and slope and the walls and floor of a pre-existing canyon; 3) the ice front retreated, Georges Bank was isolated from continental sediment sources, and the Gulf of Maine became a sediment sink, remaining so today; 4) glacial sand and gravel were ice rafted southward from the Northeast Channel and the Canadian margin and deposited on the outer part of Georges Bank and in the canyons; 5) as sea level rose, glacial sand deposited on the inner shelf was reworked and transported seaward by submarine currents, covering the outer shelf and entering the canyons.

The Georges Bank canyons apparently serve as nurseries for a number of bottom animals, including such commercially valuable species as lobster, Jonah crab, red crab, tilefish, and several kinds of hake. The young of such animals have been observed both in naturally occurring and in excavated shelters in the bottom, in both the semiconsolidated sandy silts (which look like clay) and in boulder fields. Such substrates are common in the canyons (Cooper and Uzmann, 1980 a,b). Concentrations of lobsters (juvenile and adult), for example, are substantially greater in submarine canyons than in areas nearby (Cooper and Uzmann, 1980b); lobsters seen inside the canyons are usually juveniles, while those nearby but outside the canyons are usually adults.

The steep slopes of the canyon walls are generally inaccessible to mobile fishing gear, such as dredges and otter trawls, and except for seasonal trapping, canyon inhabitants are not targets of a fishery. Hence the canyons serve as refuges for bottom species that are sought commercially elsewhere and for species that are disturbed or destroyed incidentally in the course of dredging and dragging. There is security in the canyons for a number of heavily exploited species common to the outer shelf and upper slope. In the canyons, therefore, community structure, behavior, and relations between animals and their habitats may well be represented in a virtually pristine state.

Ecology of Georges Bank Canyons

In general, assemblages of animals in the heads of various Georges Bank canyons are similar. Within these assemblages, groups that favor shallow and middle depths can be distinguished. The distinction is most clearly seen in the relative abundance of red crabs, portunid crabs, lobsters, witch flounder, ocean pout, conger eels, tilefish, squirrel hake, common grenadier, slime eels, long-nosed eels, and black-bellied rosefish. An outer shelf/upper slope faunal zone (113-299m) and a mid-slope zone (300-1099m) were found by Haedrich, Rowe, and Polloni (1975) in Alvin Canyon and by Valentine, Uzmann, and Cooper (1980a) in Oceanographer Canyon. Further evidence for this zonation in Oceanographer and Lydonia Canyon has come from Hecker (pers. comm.).

Faunal diversity and, to some extent faunal abundance, in the canyon heads appear to be closely tied to the presence of cobbles and boulders on the ocean floor and to exposures of the consolidated sandy silt into which various animals tunnel and burrow.

Georges Bank canyons exhibit a range of habitat types, as follows:

Type I habitat (Cooper et al. 1982) which occurs on the canyon rim and walls, is a featureless bottom of sand or semiconsolidated silt (claylike in consistency) with less than 5% gravel cover; a burrowing anemone characterizes this habitat.

Type II habitat is also a generally featureless bottom, of gravelly sand with at least 5% gravel cover overlying a silt substratum on the canyon rim and walls. The burrowing anemone is again characteristic – a key member of what is probably the most common association of animals in the Georges Bank canyons in depths shoaler than 400m. The tubes frequently become refuges for a variety of associated fauna, including Jonah crabs, portunid crabs, lobsters, pandalid shrimp, black-bellied rosefish, redfish, and red and silver hake. The surface of the projecting tubes also provides a consolidated surface for settlement and attachment of susbension feeders, contributing to an increased species diversity and abundance (Shepard et al. 1983).

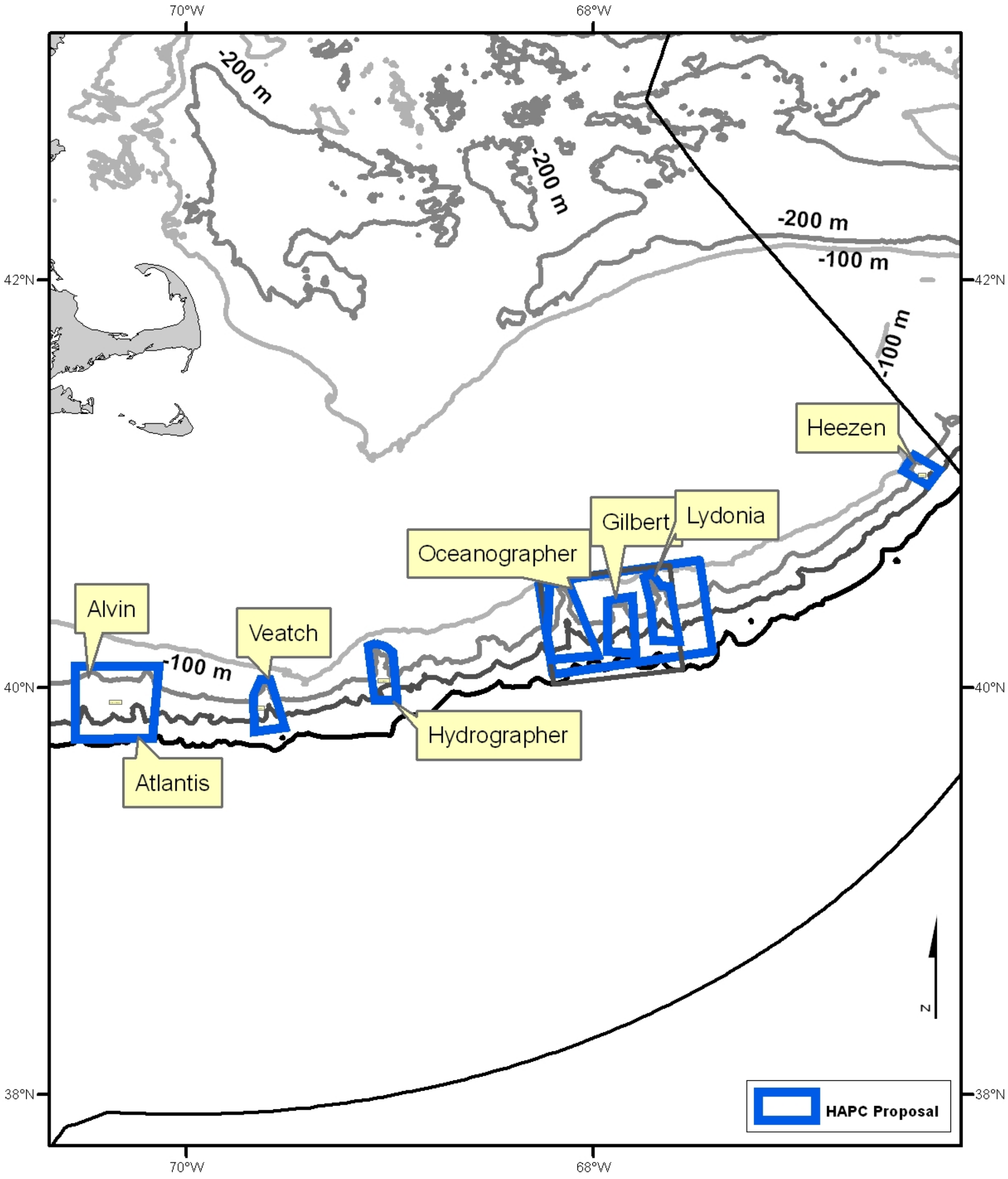
Type III habitat refers to featured, three-dimensional, very rough bottom, with siltstone outcrops and talus blocks of boulder size. These conditions are found on the rim and upper walls at the head of Oceanographer Canyon and farther down the canyon in several places at the base of the wall. White hake and ocean pout are found coexisting in surprising large numbers in this habitat. Other animals closely associated here are rock anemones, starfish, Jonah crab, and tilefish.

Type IV habitat is a featured bottom of densely burrowed, semiconsolidated silt; it occurs chiefly on the upper-to-middle canyon walls. Jonah crabs, lobsters, and tilefish predominate in this habitat. Their association is perhaps the most distinctive in the canyons; Cooper and Uzmann (1977, 1980a,b) have called it the "pueblo village" community. Type IV habitat has been found at depths of 150-1000m on the canyon walls, but is most evident at shoaler depths (150-300m). Pueblo villages deeper than 300 m are occupied primarily by red crab, Jonah crab, white hake, and ocean pout. The apex predator of the villages is the tilefish. Pueblo villages appear to be the prime habitat and "home ground" of offshore lobsters. Some 20-50% of the adult population migrates onshore from the villages in the spring and early summer (Uzmann, Cooper, and Pecci, 1977; Cooper and Uzmann, 1980a,b), returning in the late summer and fall.

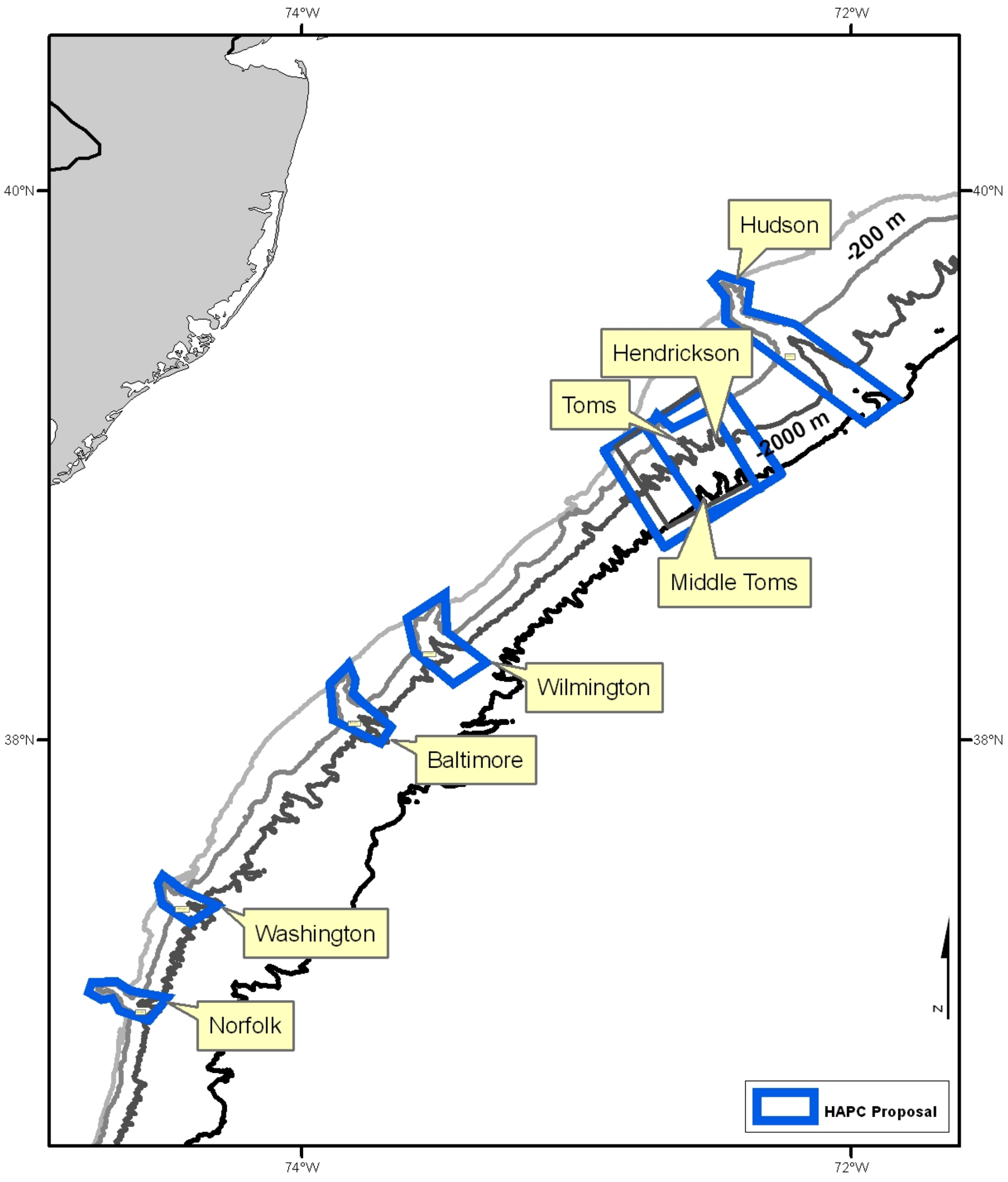
Type V habitat refers to duned sand on the canyon floor. This has been found only in Oceanographer Canyon, from the very northern end south to a depth of at least 700m.

INSERT REFERENCES???

Map 5. Northern Deep-Sea Canyon HAPC Alternatives.



Map 6. Mid-Atlantic Deep-Sea Canyon HAPC Alternatives



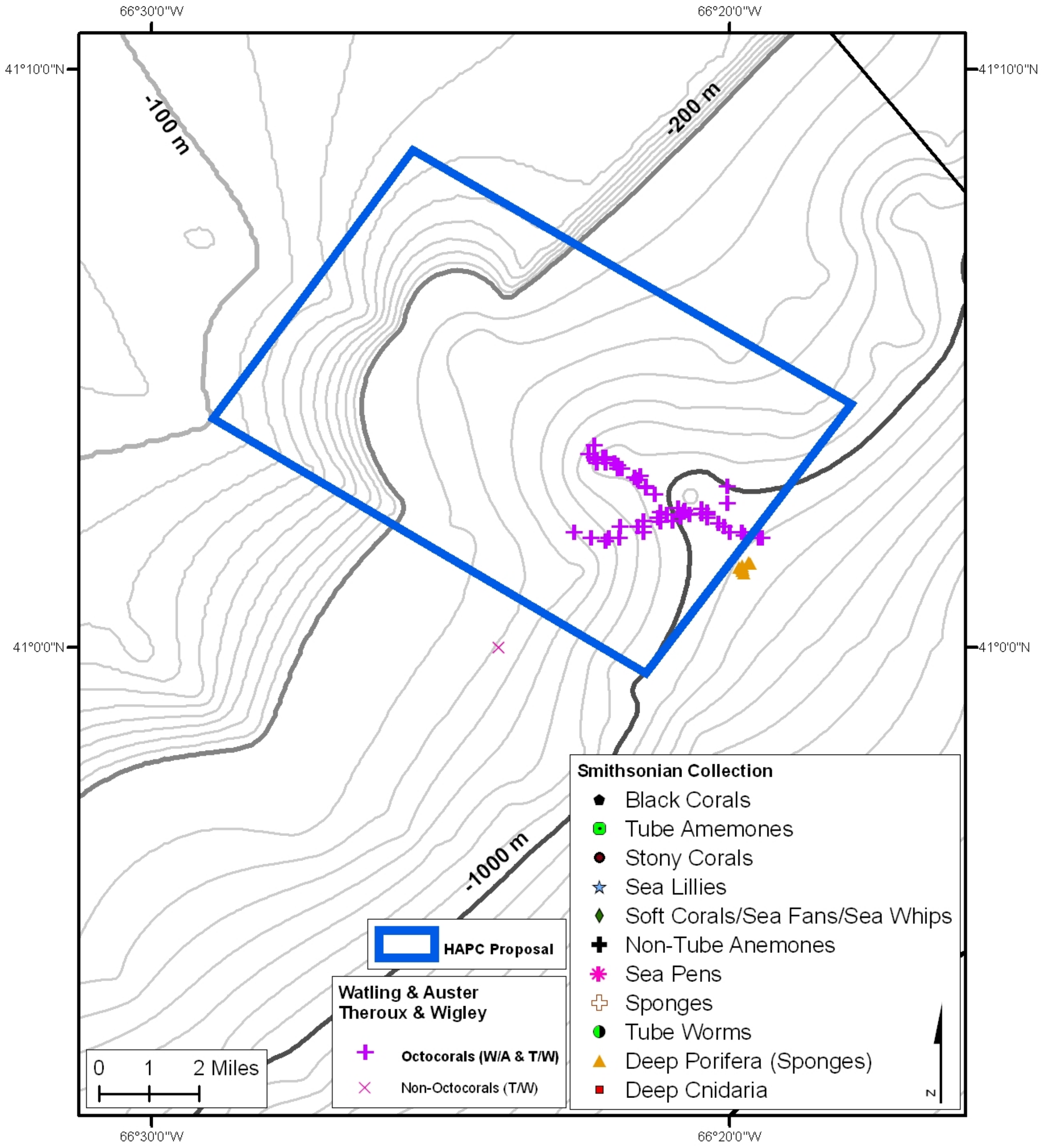
List of Canyon HAPC Alternatives

The following canyons* will be considered by the Council as individual HAPC alternatives (from NE to SW):

** With documented presence of structured forming organisms.*

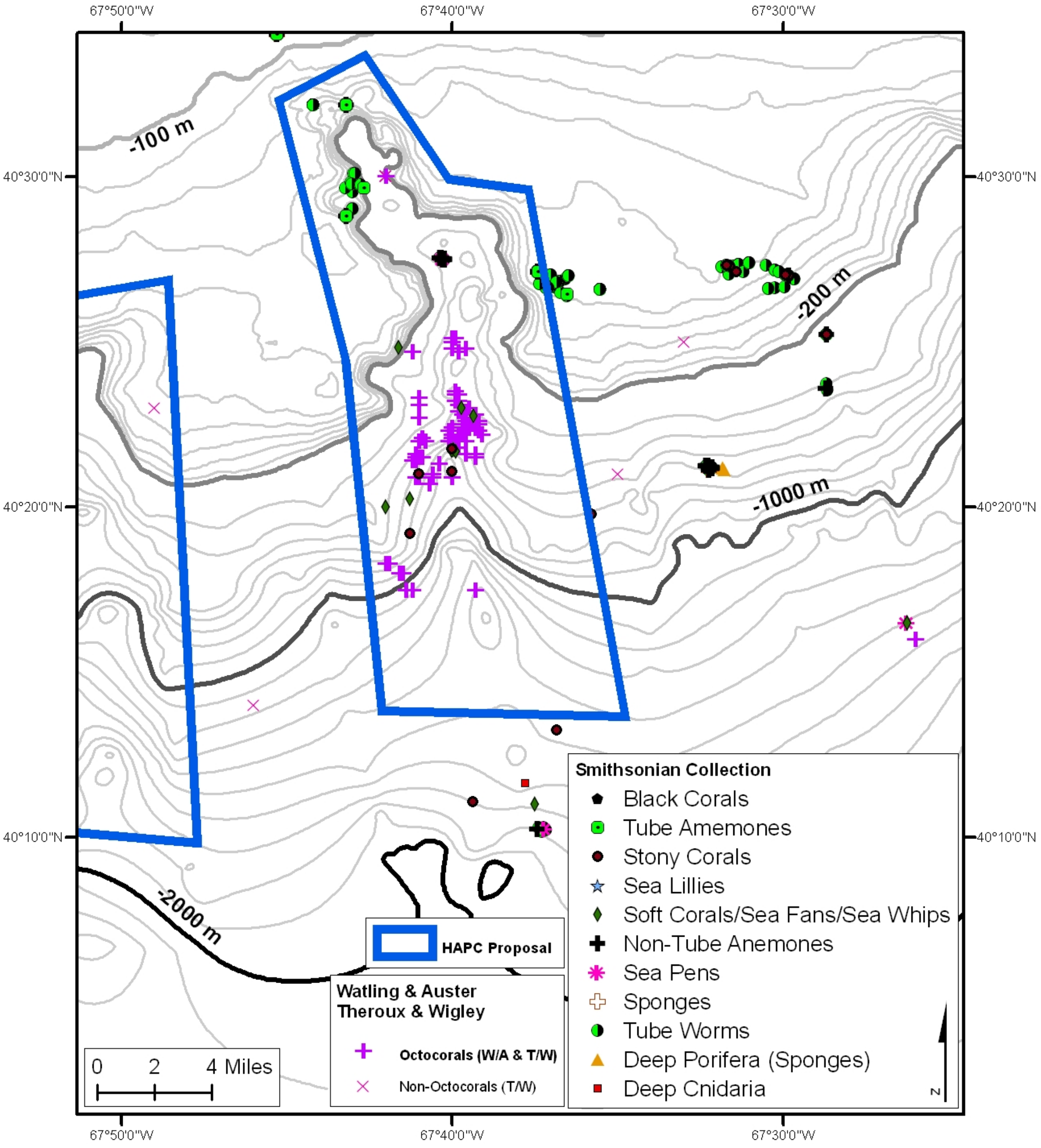
3.1.3.1 Alternative 3A: Heezen Canyon

Map 7. Alternative 3A: Heezen Canyon



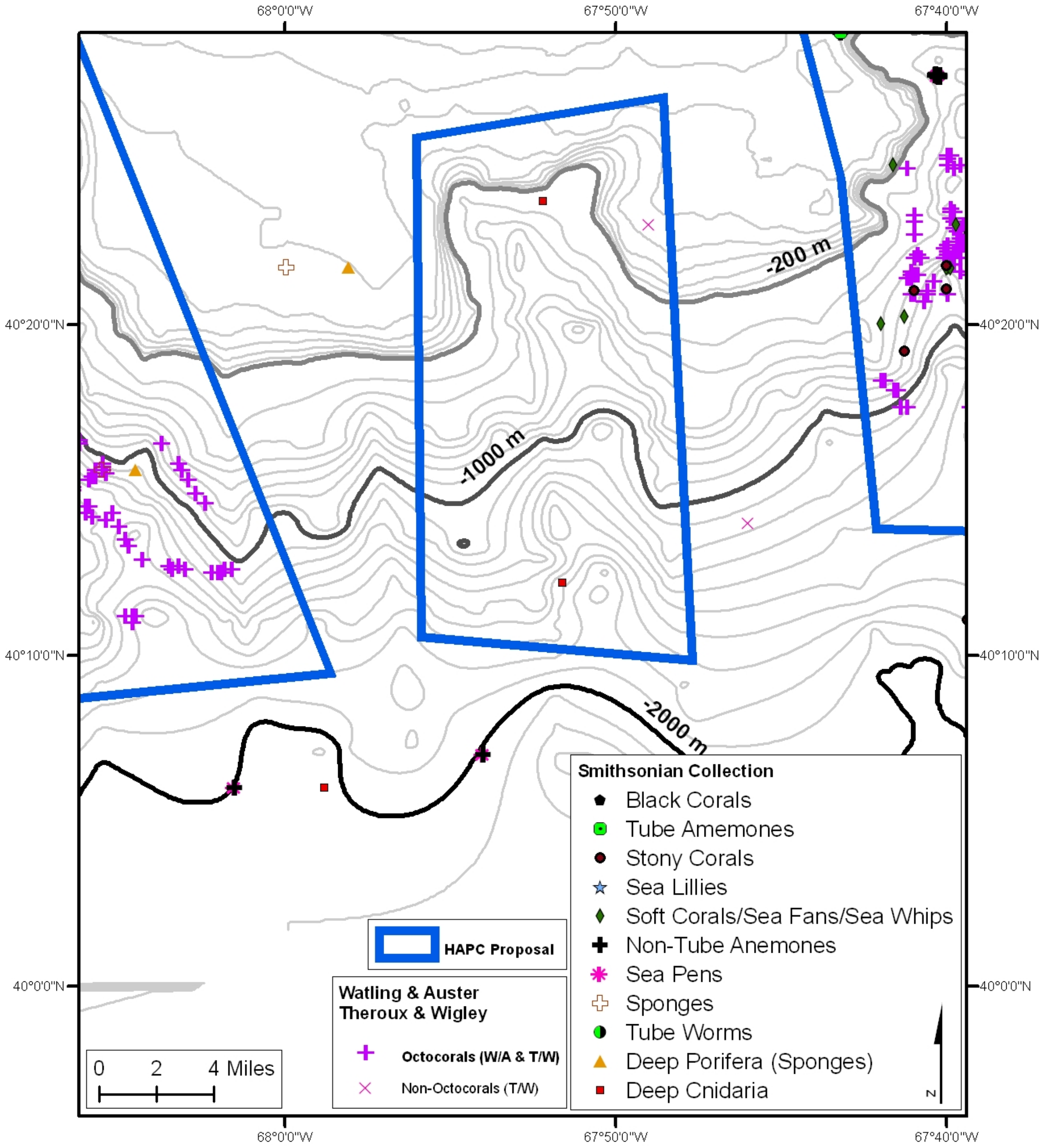
3.1.3.2 Alternative 3B: Lydonia Canyon

Map 8. Alternative 3B: Lydonia Canyon



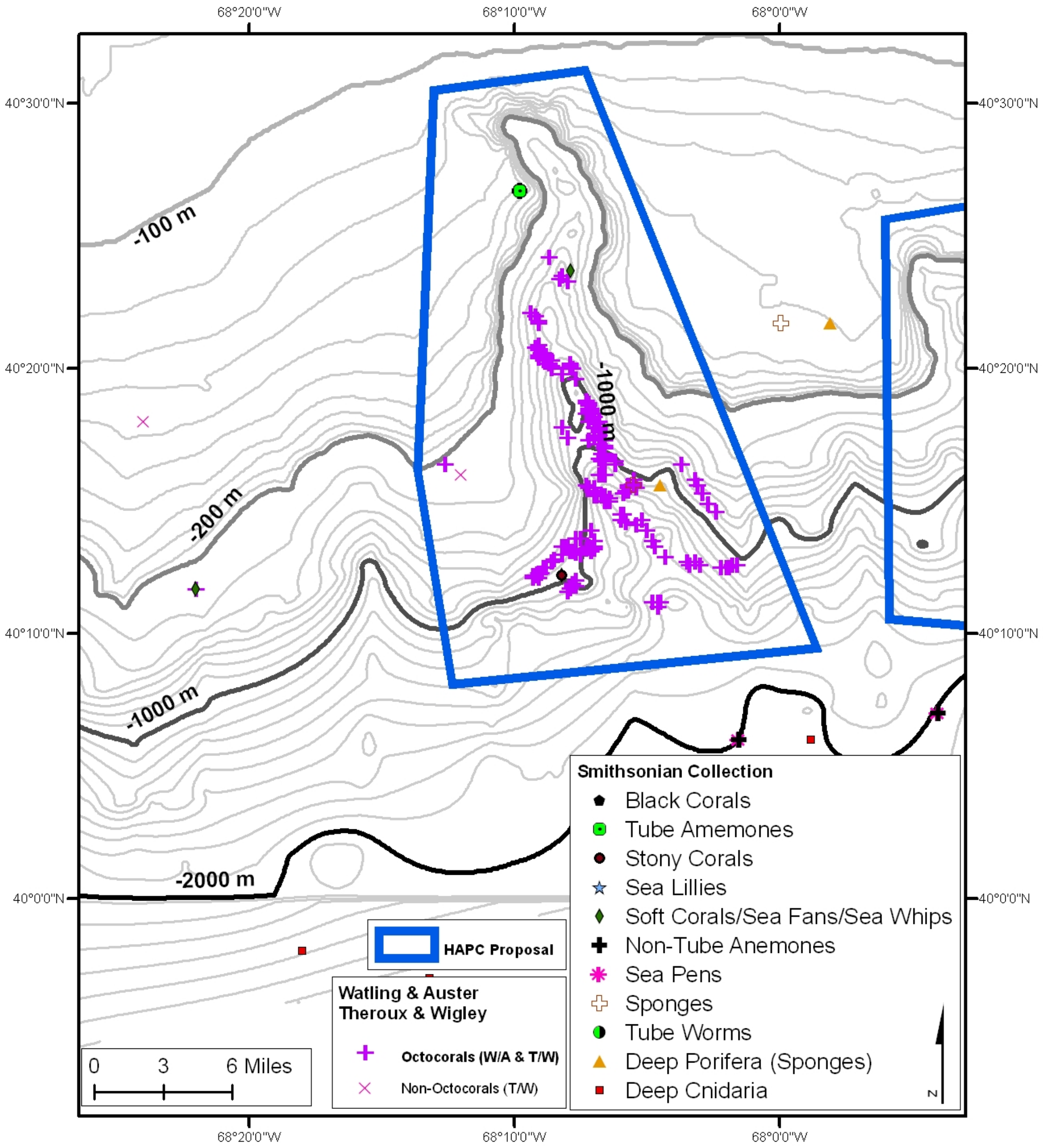
3.1.3.3 Alternative 3C: Gilbert Canyon

Map 9. Alternative 3C: Gilbert Canyon



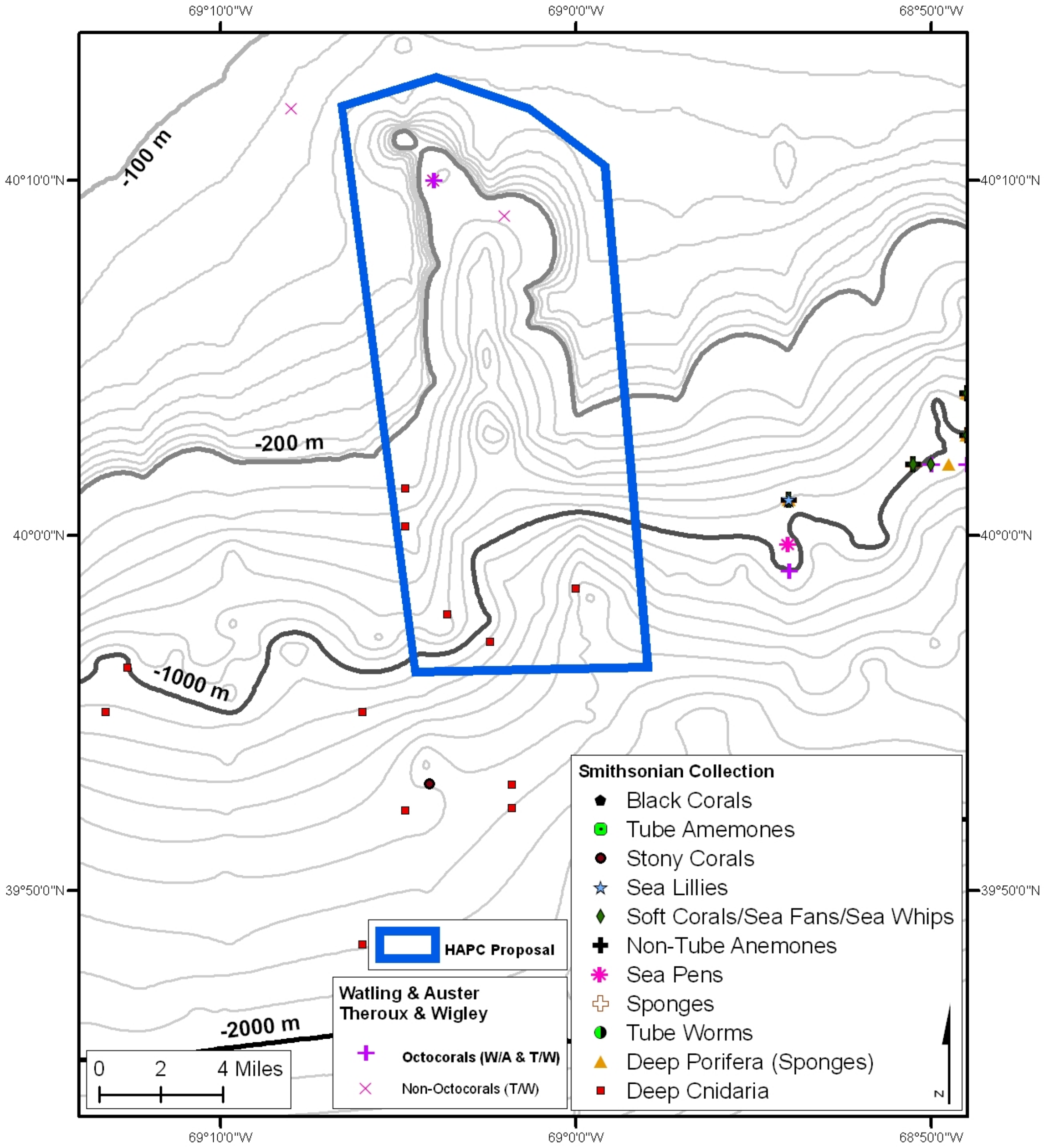
3.1.3.4 Alternative 3D: Oceanographer Canyon

Map 10. Alternative 3D: Oceanographer Canyon



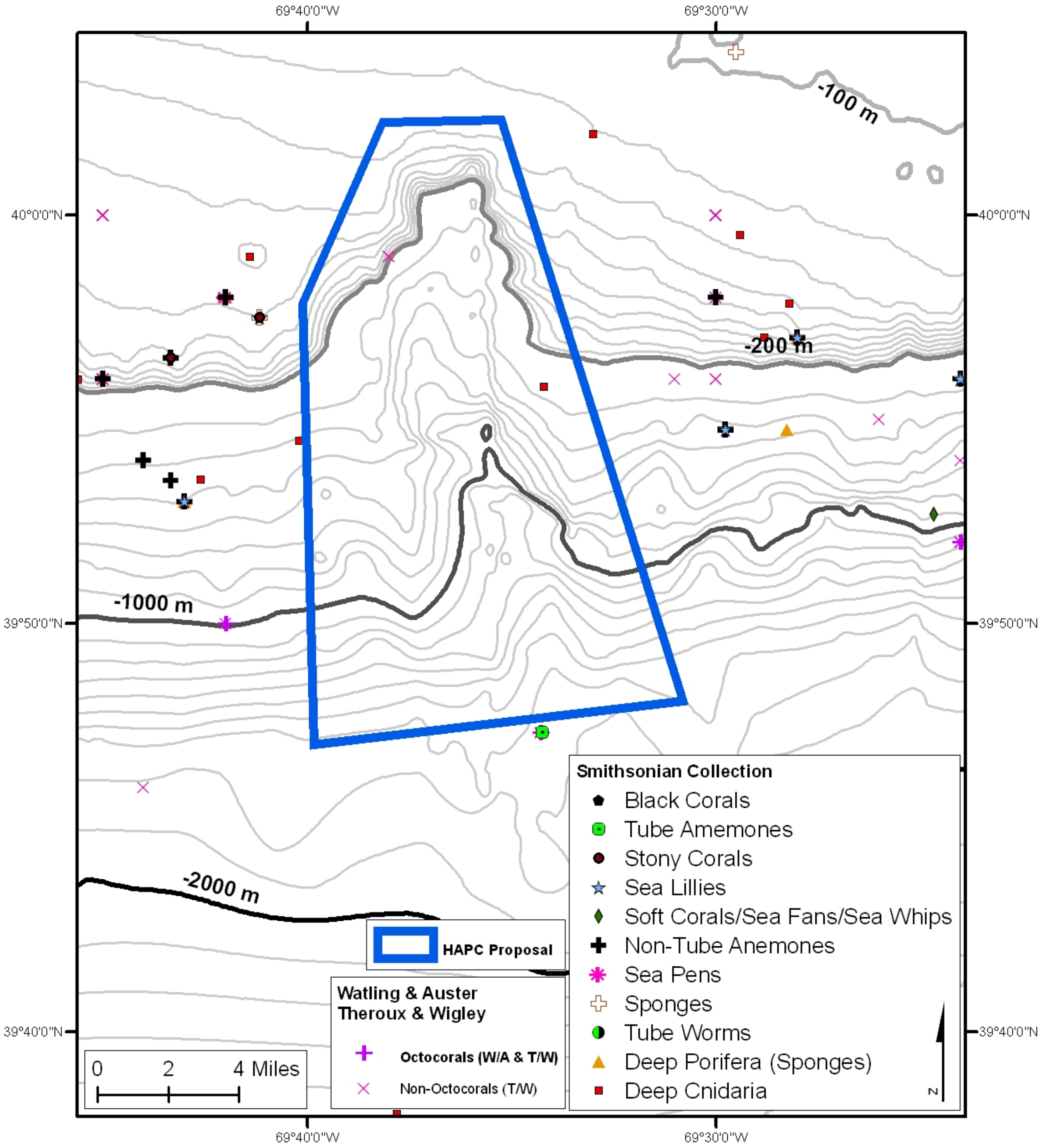
3.1.3.5 Alternative 3E: Hydrographer Canyon

Map 11. Alternative 3E: Hydrographer Canyon



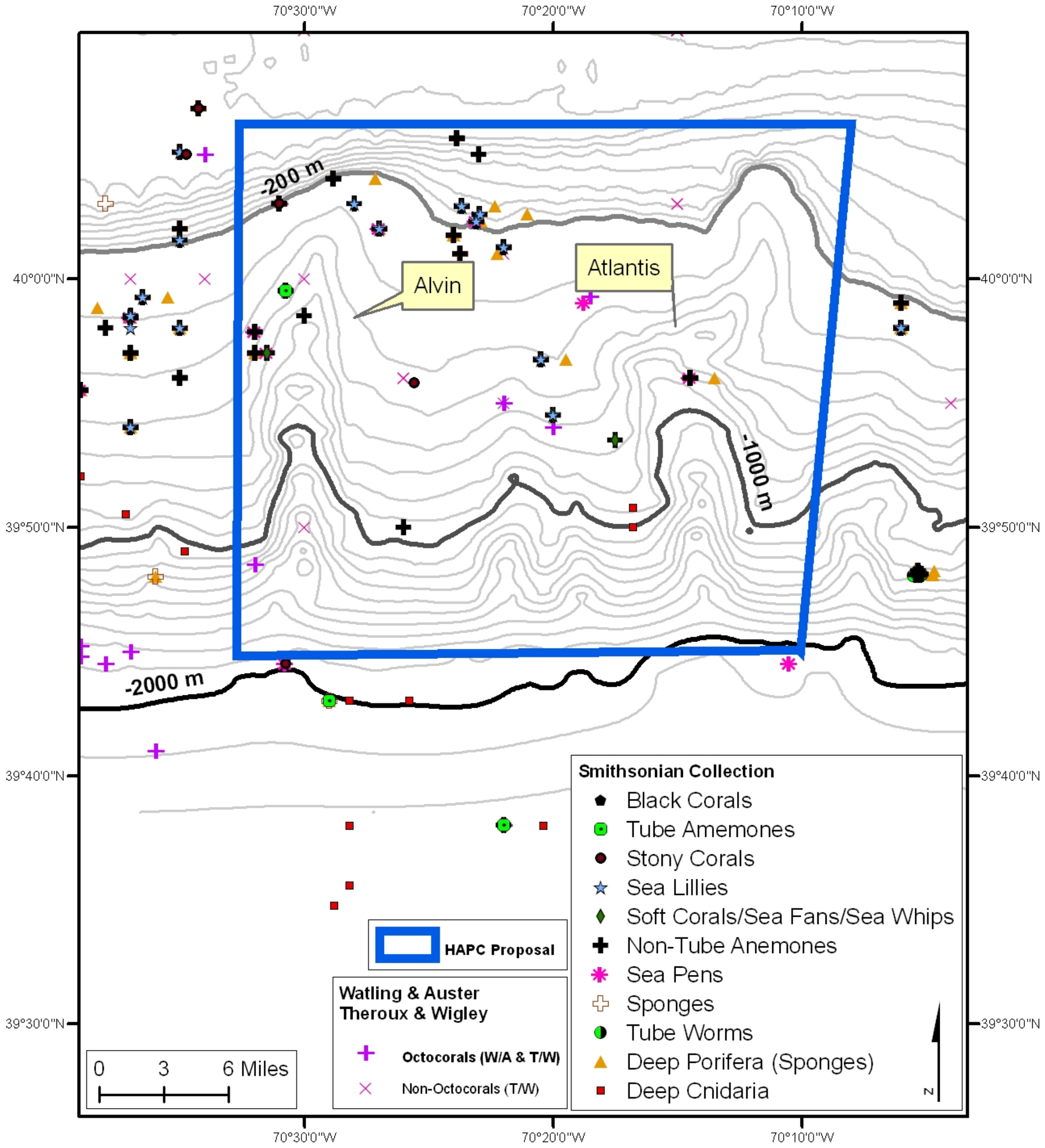
3.1.3.6 Alternative 3F: Veatch Canyon

Map 12. Alternative 3F: Veatch Canyon



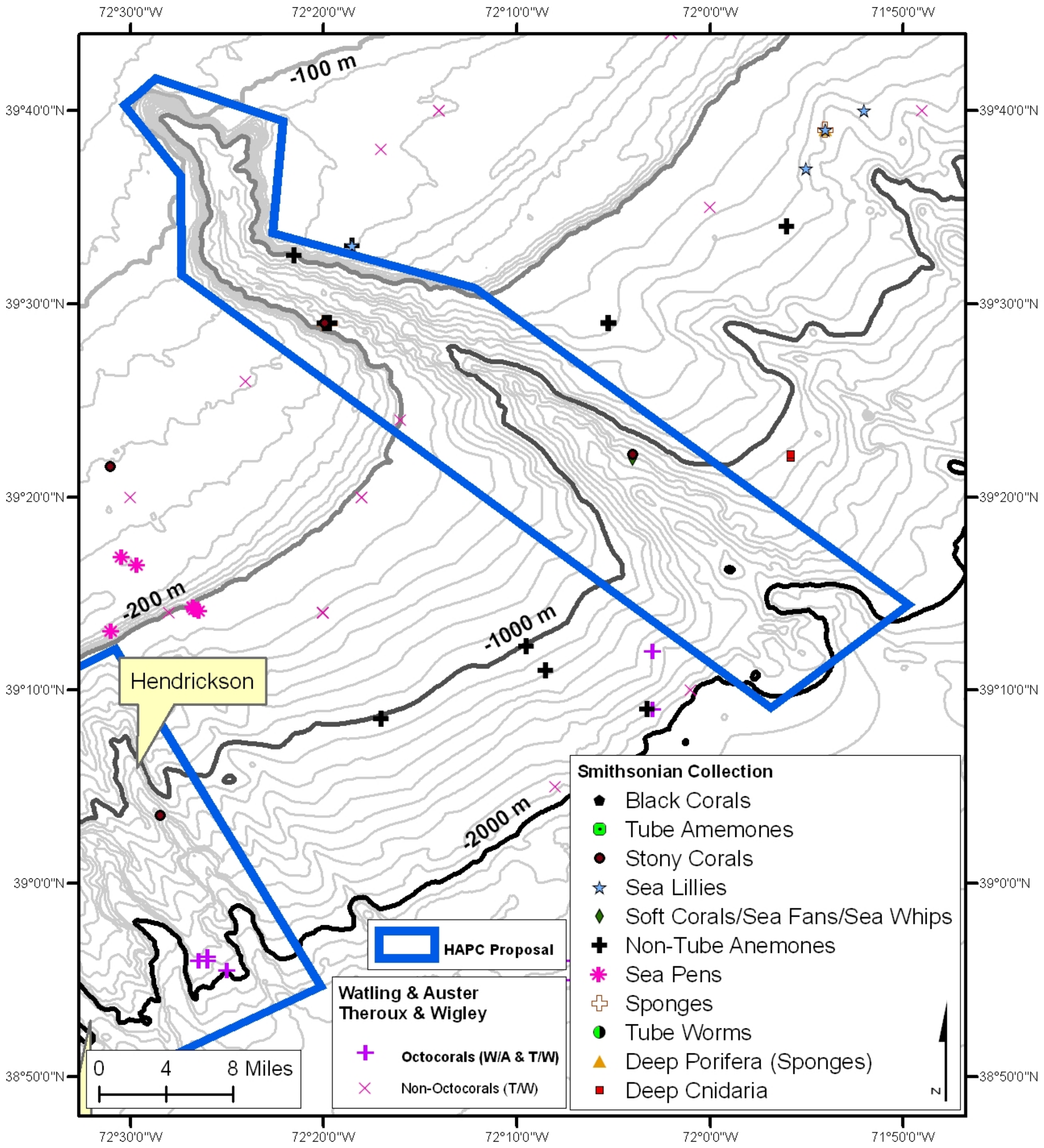
3.1.3.7 Alternative 3G: Alvin and Atlantis Canyons

Map 13. Alternative 3G: Alvin and Atlantis Canyons



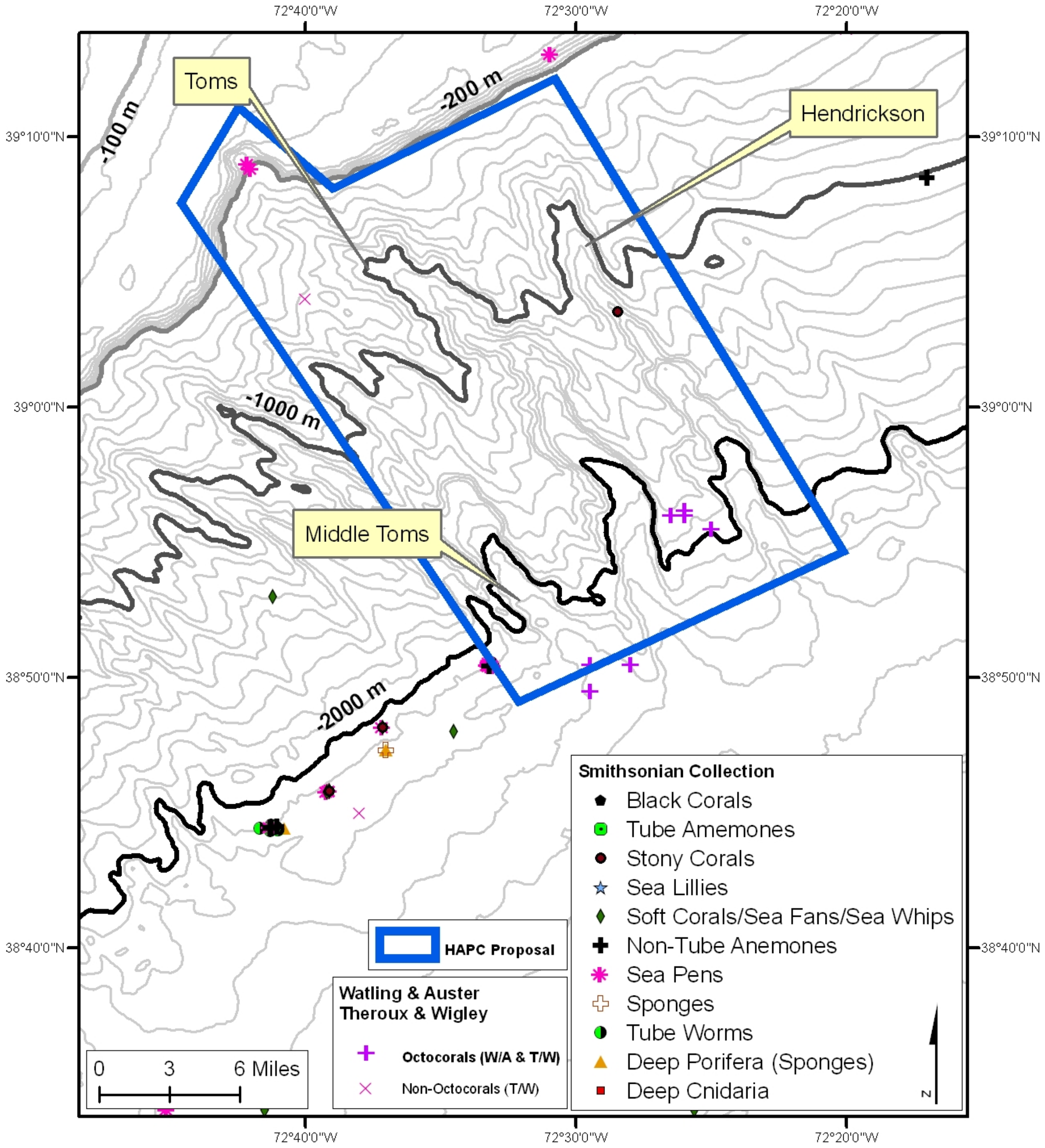
3.1.3.8 Alternative 3H: Hudson Canyon

Map 14. Alternative 3H: Hudson Canyon



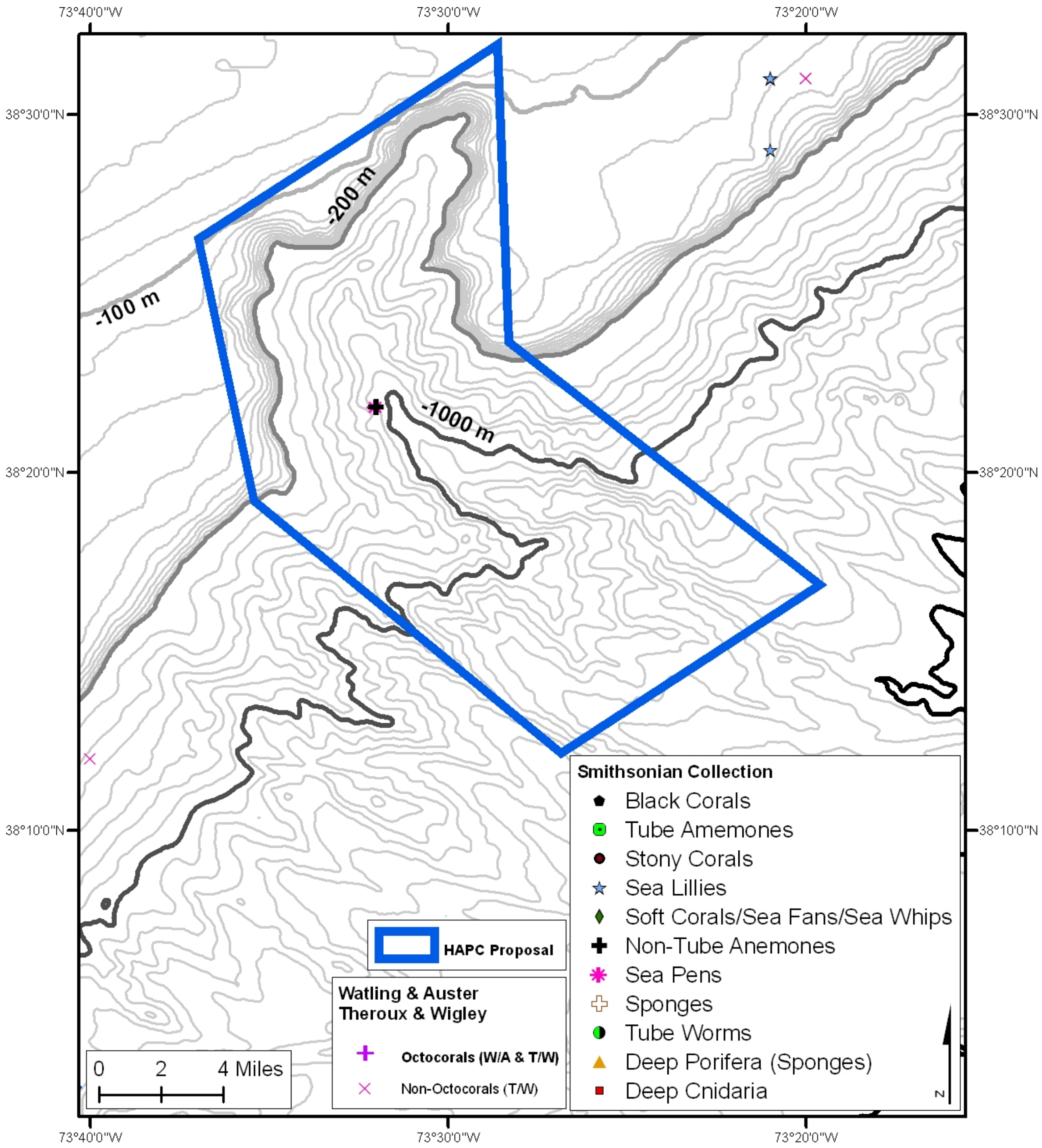
3.1.3.9 Alternative 3I: Toms and Hendrickson Canyons

Map 15. Alternative 3I: Toms and Hendrickson Canyons



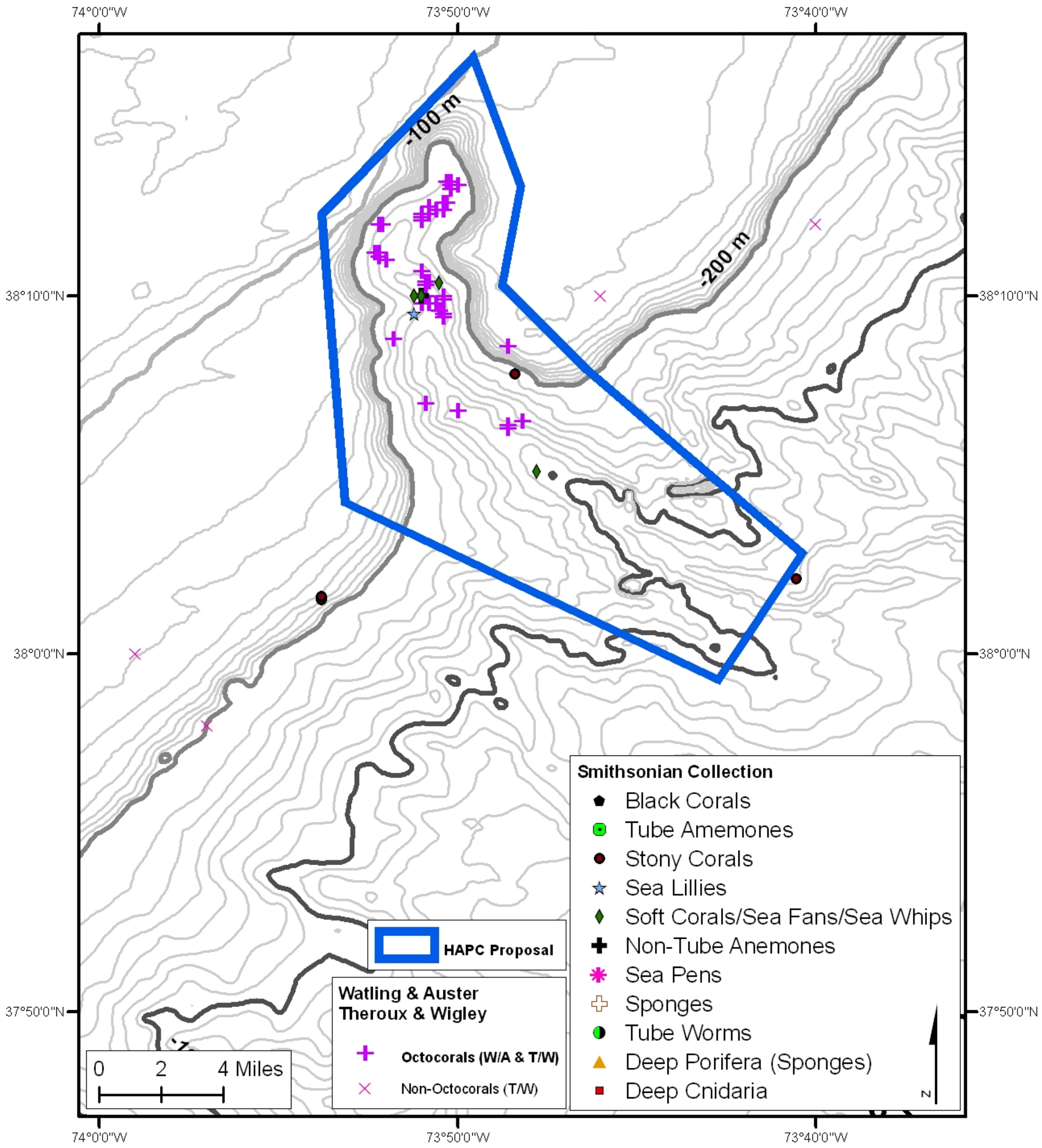
3.1.3.10 Alternative 3J: Wilmington Canyon

Map 16. Alternative 3J: Wilmington Canyon



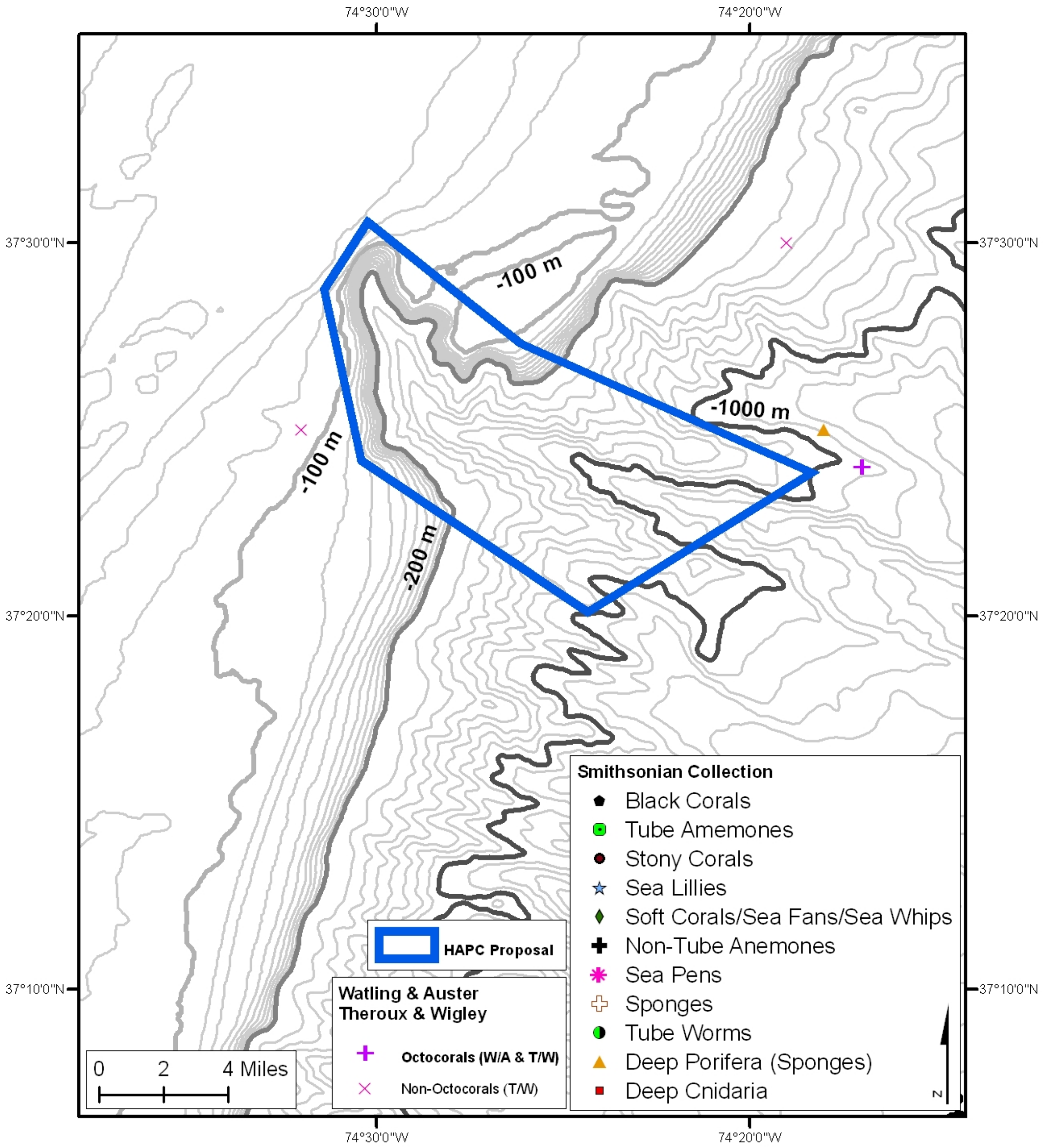
3.1.3.11 Alternative 3K: Baltimore Canyon

Map 17. Alternative 3K: Baltimore Canyons



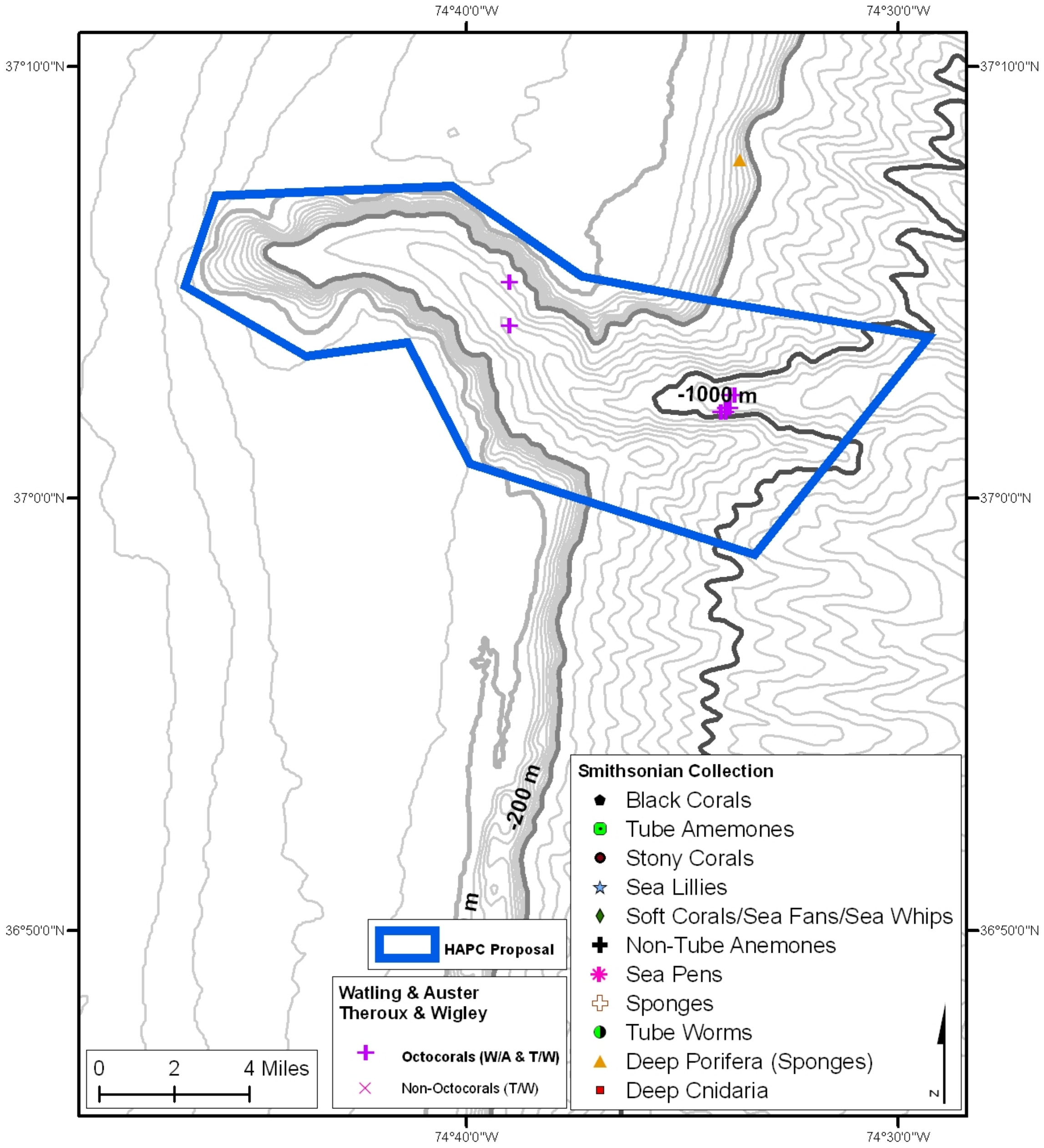
3.1.3.12 Alternative 3L: Washington Canyon

Map 18. Alternative 3L: Washington Canyons



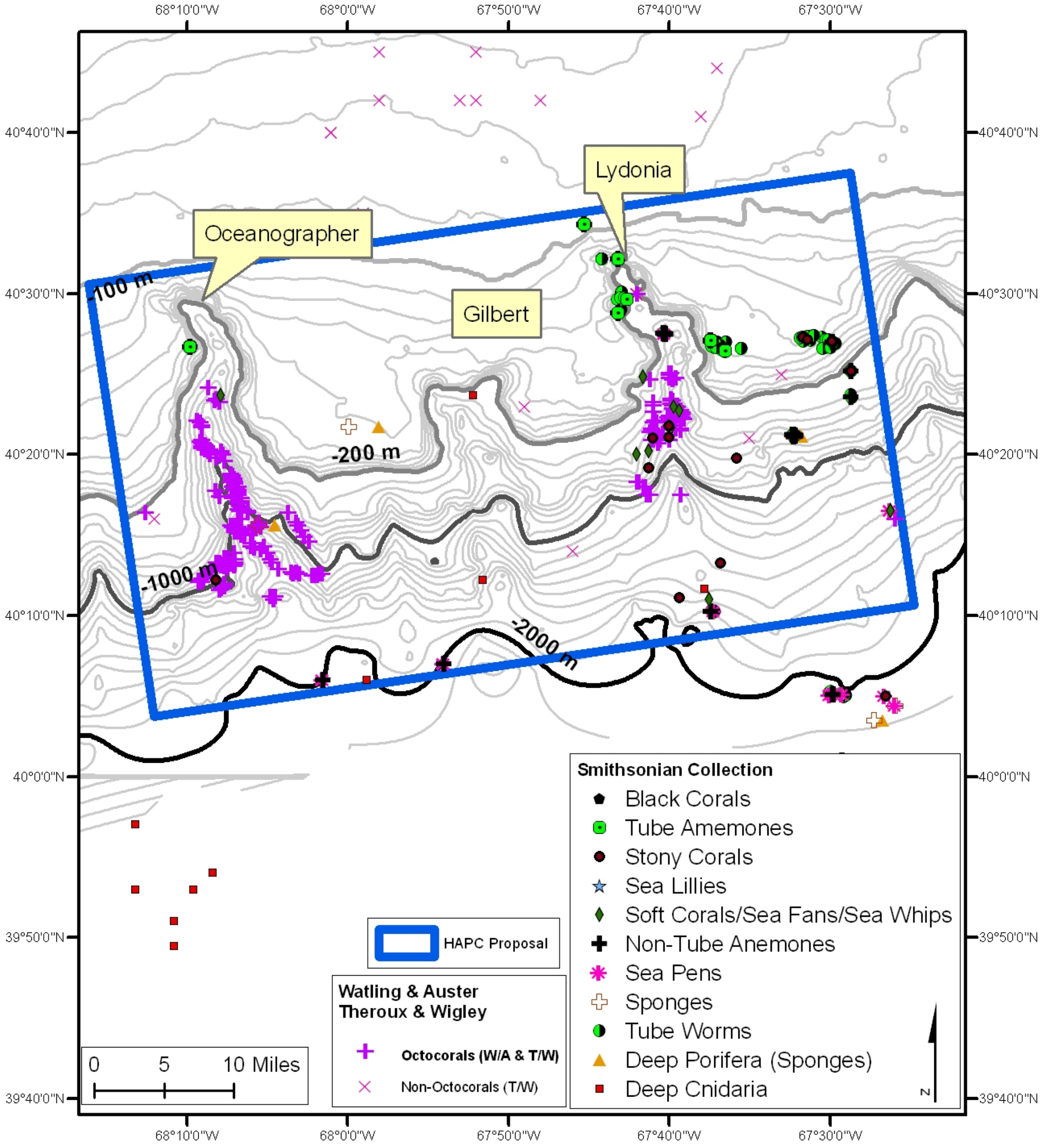
3.1.3.13 Alternative 3M: Norfolk Canyon

Map 19. Alternative 3M: Norfolk Canyon



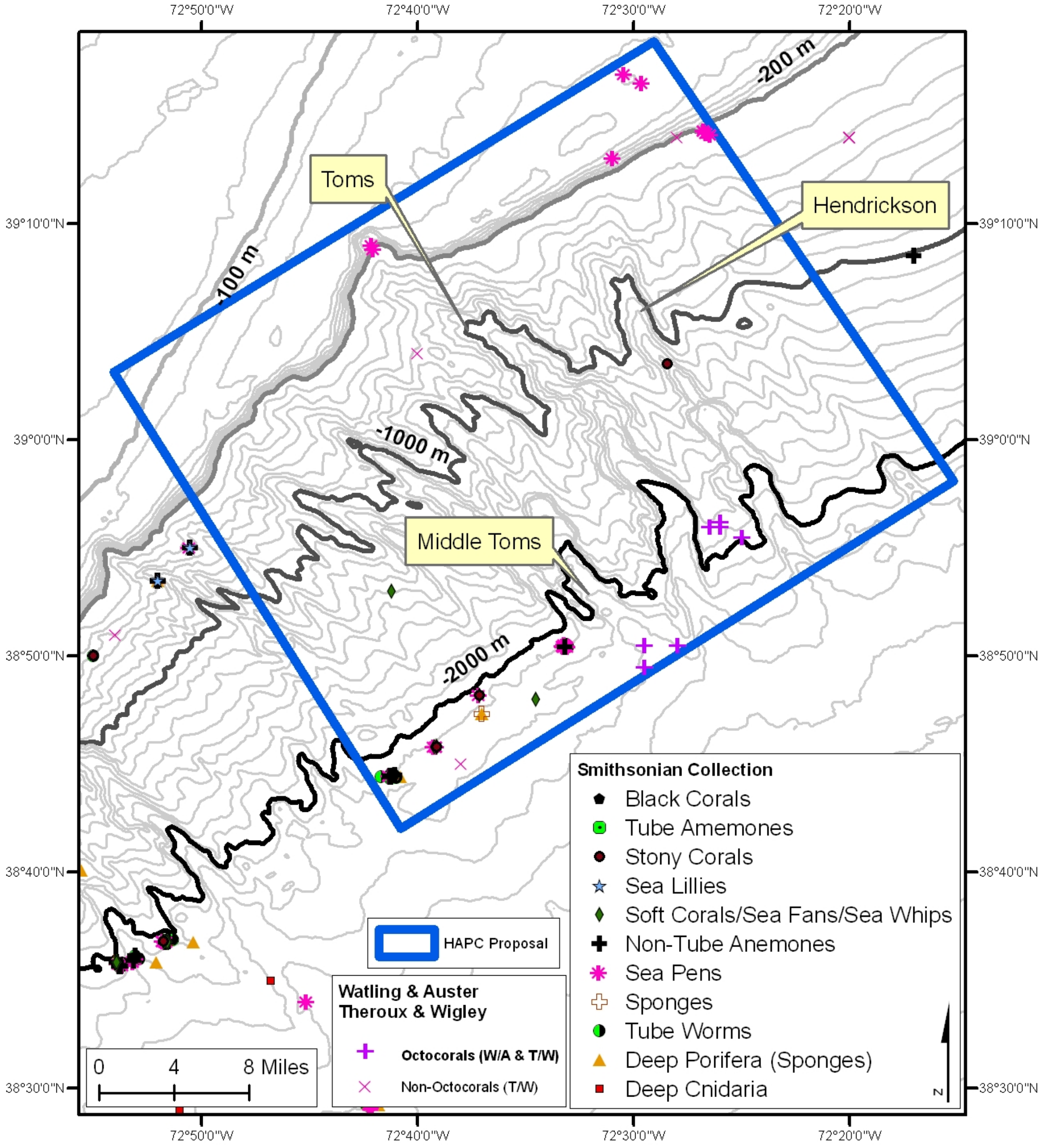
3.1.3.14 Alternative 3N: Oceanographer, Gilbert and Lydonia Canyons

Map 20. Alternative 3N: Oceanographer, Gilbert and Lydonia Canyons



3.1.3.15 Alternative 3O: Toms, Hendrickson and Inter-Canyon Areas

Map 21. Alternative 3O: Toms, Hendrickson and Inter-Canyon Areas



3.1.4 Alternative 4: Cashes Ledge Area

Overview

This alternative (Map 22) seeks to extend the boundaries of the Cashes Ledge Habitat Closed Area in order to include deeper water habitats and ridges associated with Cashes Ledge. Cashes Ledge is a granitic ridge located in the central Gulf of Maine which, including Ammen Rock Pinnacle, rises to within 26 meters of the ocean surface. The top of Cashes Ledge is primarily a steeply sided granitic outcrop that grades to boulder-talus-ledge, then cobble-sand and small outcrops, and finally sand-gravel as depth increases beyond approximately 75 m. Several unique features contribute to the ecological importance of the Cashes Ledge area. Productivity in the Cashes Ledge area is noteworthy because the area generates and receives internal waves that drive thick, plankton-rich layers down to the ledge (Witman et al. 1993). Dense aggregations of habitat forming invertebrates such as horse mussels, sea anemones, and sponges thrive on the productivity of the area and flourish along many of the peaks that distinguish the area (Witman and Sebens 1988, Lesser et al. 1994, Genovese and Witman, 1999, Hill et al. 2002) while burrowing anemones are abundant in the sand-gravel matrix beyond the base (Witman and Sebens 1988). The unique ecological features of Cashes Ledge include the presence of one of the largest and deepest continuous kelp beds in the Gulf of Maine. Further, production of benthic macroalgae on Ammen Rock Pinnacle occurs at a record 63 m depth. The Cashes Ledge area continues to support a high abundance of large bodied predators such as cod, wolffish, pollock, and sharks (Steneck 1997, Steneck and Carlton 2001, Steneck et al 2002, Witman and Sebens 1992), that are generally absent from rocky habitats along the coast of the Gulf of Maine. Fish may aggregate or have higher survival after settlement in the Cashes Ledge area due to increased availability of shelter (e.g., kelp forests, structure forming invertebrates) and abundant prey mediated by high water flow from nutrient-rich internal waves and other strong-current producing forces (Witman et al. 1993, Leichter and Witman 1997, Genovese and Witman 1999).

The unique oceanographic characteristics and habitat features found in the area satisfy many of the HAPC designation criteria, including importance of ecological function, sensitivity to human-induced degradation, and rarity of habitat type as well the Council's stated preference for areas that are designated EFH for more than one species.

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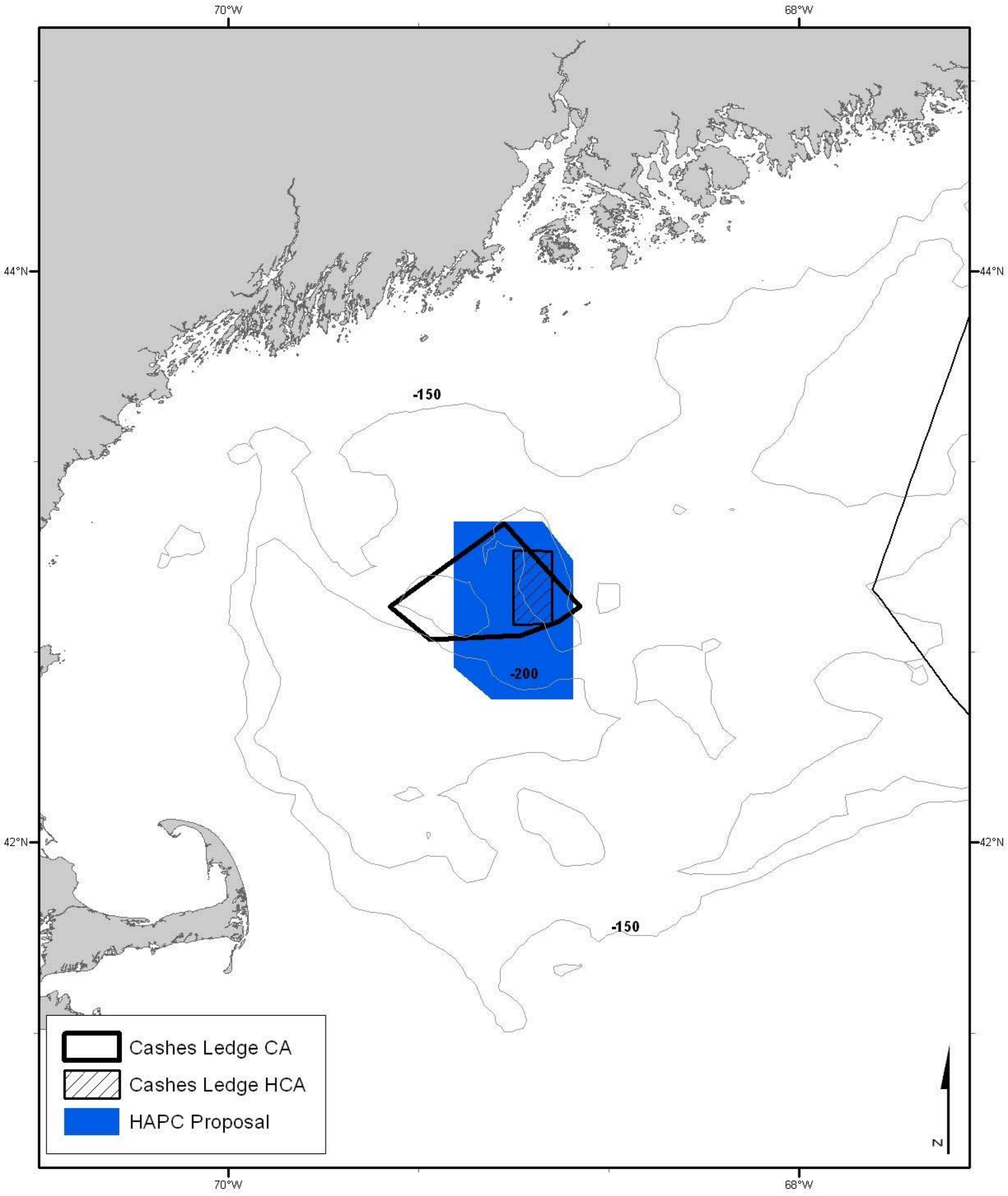
Map 22. Alternative 4: Cashes Ledge Area HAPC Alternative



3.1.5 Alternative 5: George's Bank / Northern Edge Area

Overview

The purpose of this alternative (Map 23) is to expand the existing HAPC designation westward to encompass more gravel, cobble, and boulder habitat features known to improve the survival of juvenile cod and other species. The existing HAPC is bounded on the west at 67° 20′ by the western side of Closed Area II. However, the gravel pavement extends further to the west (Valentine and Lough 1991) and would be included in the proposed alternative. This proposal would also apply the HAPC to all species and life stages with EFH designated in the area, not just juvenile cod. The unique oceanographic characteristics and habitat features found in the area satisfy many of the HAPC designation criteria, including importance of ecological function, sensitivity to human-induced environmental degradation, and rarity of habitat type. Gravel substrate is found only on the northern edge of Georges Bank and in patches in the Great South Channel. The northern edge of Georges Bank has a high level of biological production, fueled by nutrient-rich water upwelled from the Gulf of Maine. This area contains horse mussel beds, and the cobble substrate provides suitable attachment sites for colonial epifauna such as hydroids and sponges. However, this area has been more heavily fished since the establishment of Closed Area II and there is presently little epifaunal cover (Collie et al. 2005). The southern part of the proposed HAPC, on either side of the Closed Area II boundary (67° 20′) is heavily infested with the colonial tunicate, *Didemnum* sp (personal observation from our cruise).

Collie, J.S., Hermsen, J.M., Valentine, P.C., and F.P. Almeida. 2005. Effects of fishing on gravel habitats: assessment and recovery of benthic megafauna on Georges Bank. Pages 235-343 *In* P. Barnes and J. Thomas [eds.] Benthic habitats and the effects of fishing. American Fisheries Society, Bethesda, MD.

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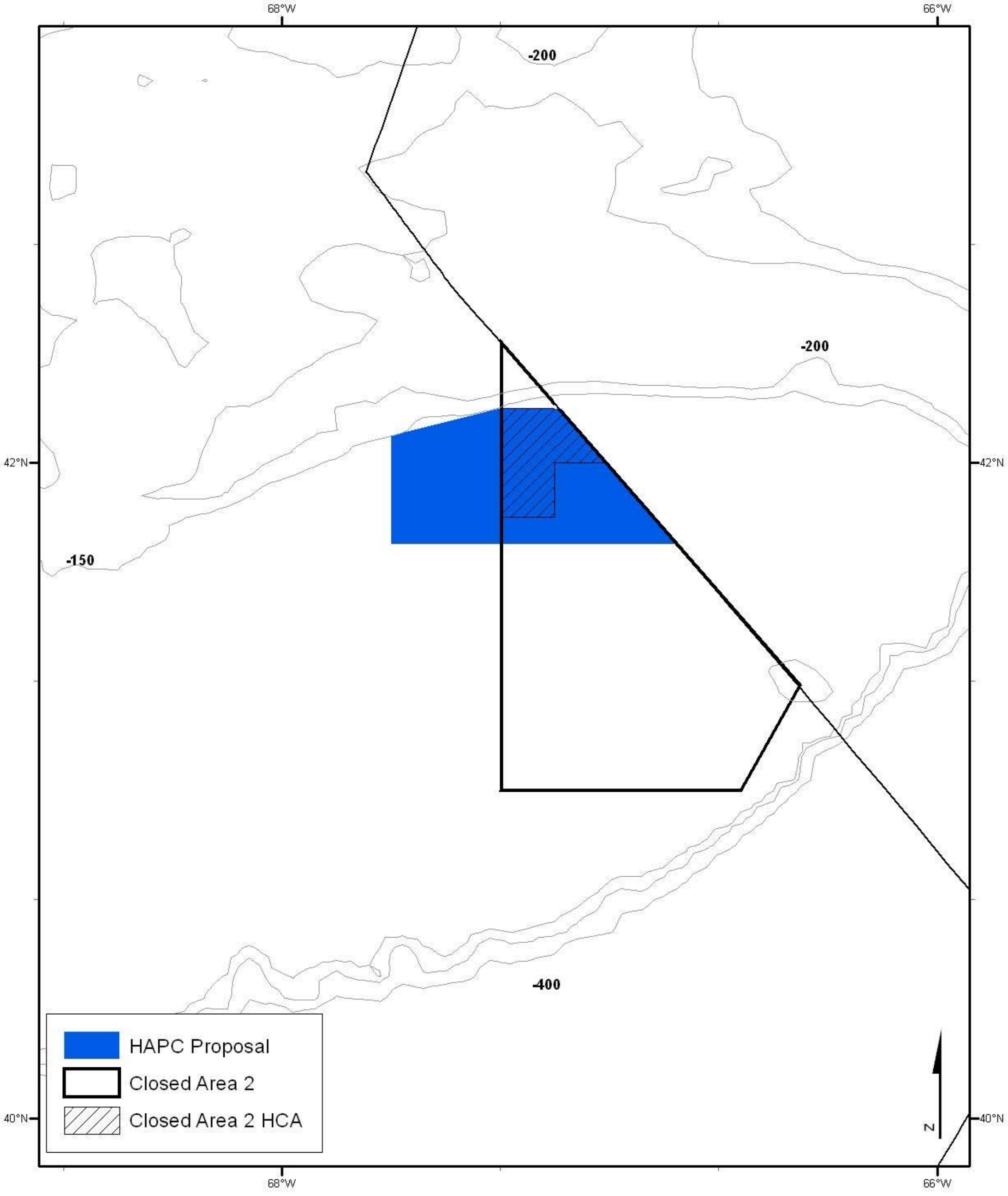
Map 23. Alternative 5: George's Bank / Northern Edge HAPC Alternative



3.1.6 Alternative 6: Jeffreys Ledge / Stellwagen Bank Area

Overview
This alternative (**M**ap 24 - Map 26) seeks to designate portions of Jeffreys Ledge and Stellwagen Bank as diverse and highly productive habitat features within the Gulf of Maine.

This alternative includes three options for public comment:

Option A: Designate as HAPC the Western Gulf of Maine Habitat Closed Area (**M**ap 24)

Option B: Designate as HAPC the Western Gulf of Maine Groundfish Closure plus a westward extension into the Stellwagen Bank National Marine Sanctuary (Map 25)

Option C: Designate as HAPC the Western Gulf of Maine Groundfish Closure and the Stellwagen Bank National Marine Sanctuary in their entirety (Map 26)

Jeffreys Ledge and Stellwagen Bank are shallow, glacially formed features that include a diversity of habitat types, including gravel/cobble substrates, boulder reefs, sand plains, and deep mud basins in a complex matrix. Oceanographic currents driven by the Gulf of Maine Coastal Current as well as from the impingement of internal waves deliver nutrient-rich waters to the area and the topographic features of the area result in upwelling that drives production. The complex matrix of sedimentary habitats support a wide diversity of structure forming invertebrates including frilled anemones, burrowing anemones, sponges, bryozoans, ascidians, cold water corals (Auster et al. 1998, Grannis 2001, Tamsett in prep). Such habitats are important areas for recruitment and survival of species such as cod, haddock, cusk, Acadian redfish, silver hake and a diversity of flounders (e.g., Auster et al. 2001, 2003a, 2003b). Further, the Jeffreys Ledge-Stellwagen Bank area supports a high diversity of fishes compared to many other areas in the Gulf (Auster 2002, Auster et al. in prep). Unique aspects of the habitats contained within the proposed HAPC include their extreme depth range, which bathes these features in Maine surface and intermediate waters, as well as the fact that they represent the wide diversity of habitat types in the Gulf of Maine in a discrete location. The unique oceanographic characteristics and habitat features found in the area satisfy many of the HAPC designation criteria, including importance of ecological function, sensitivity to human-induced degradation, rarity of habitat type, existence of current and/or future development stresses.

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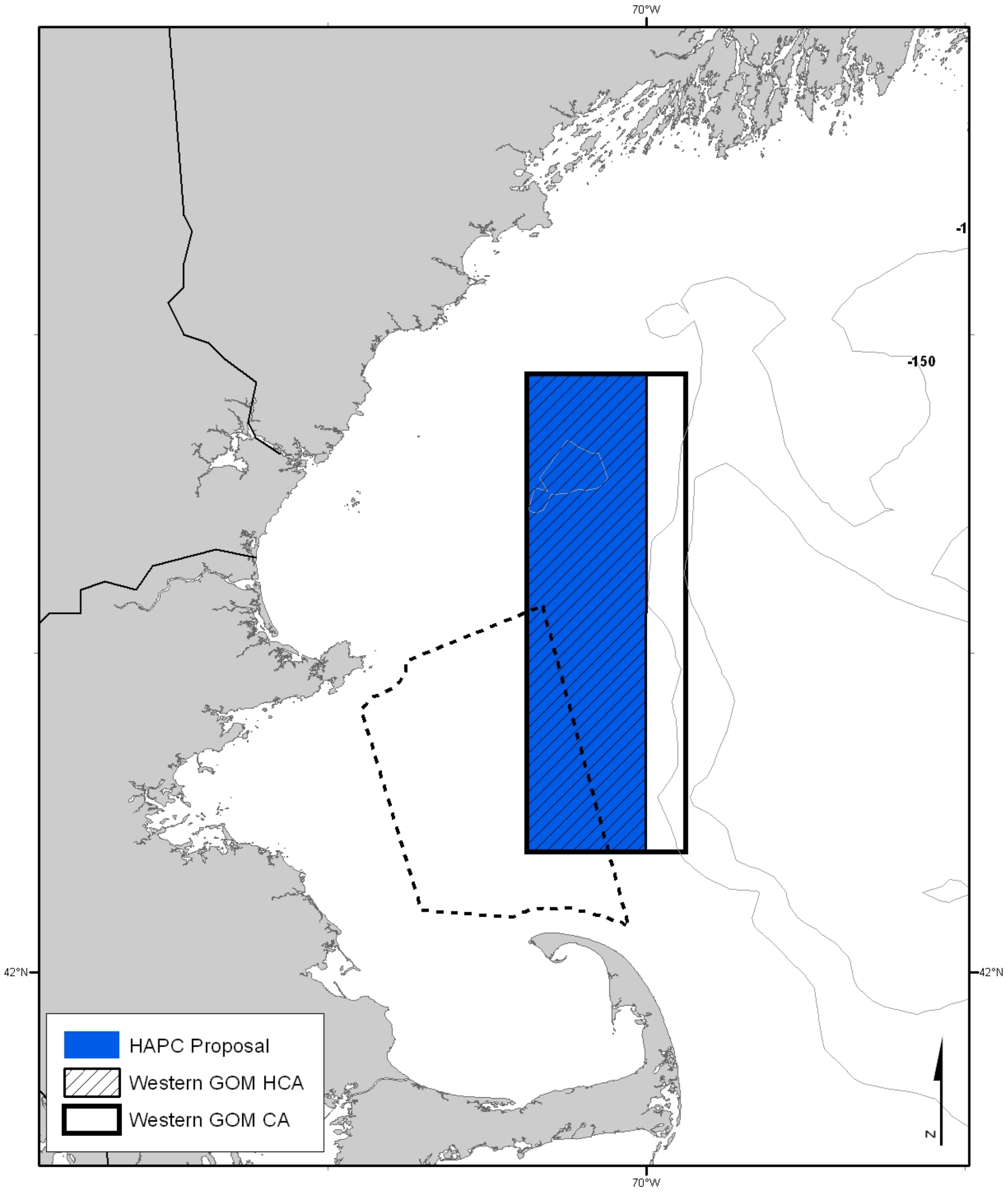
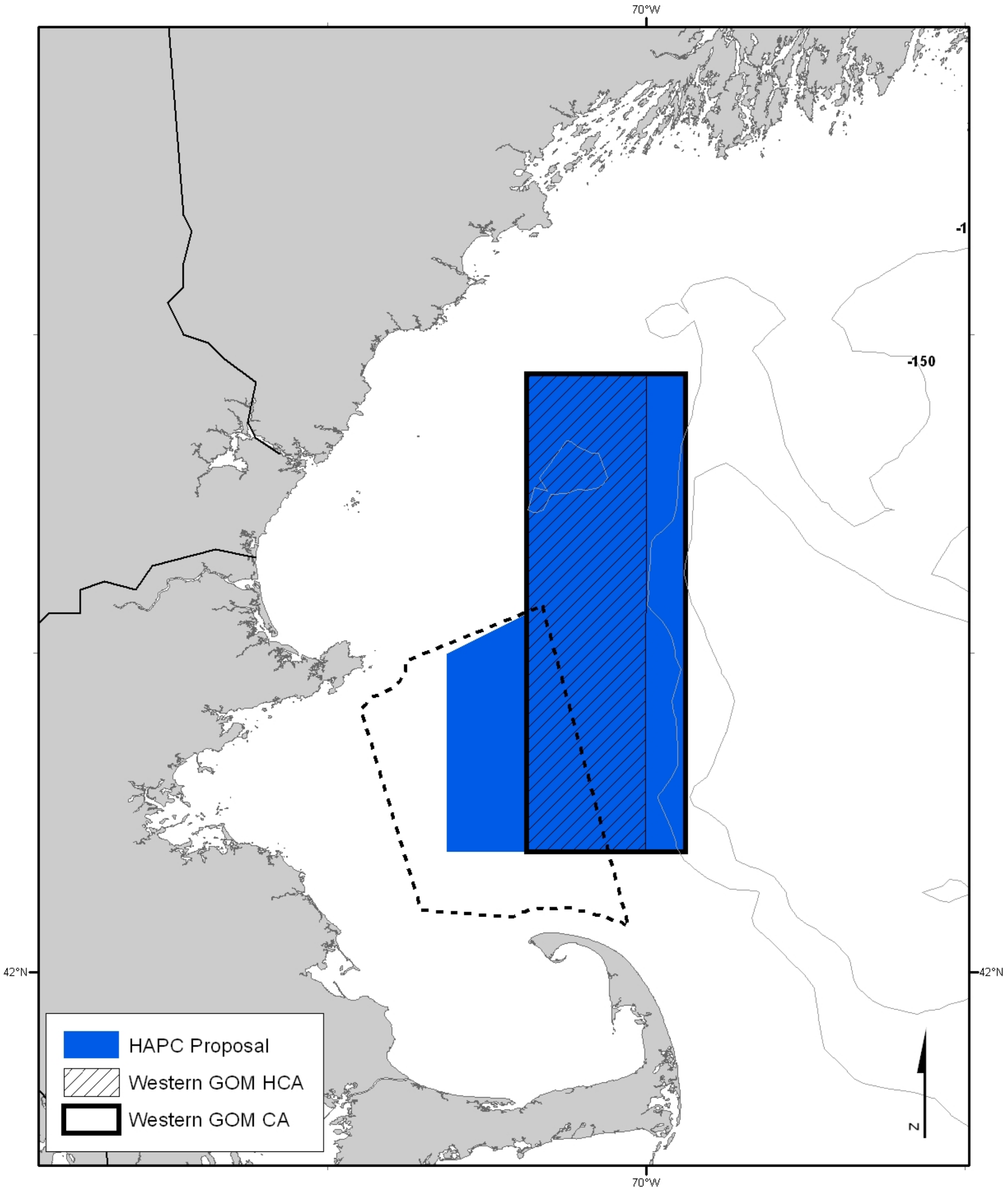
Tamsett, A. In Preparation. Fishing Effects on Epifaunal Communities, and the Role of Attached Epifauna as Fish Habitat. M.S. Thesis. University of Connecticut, Storrs.

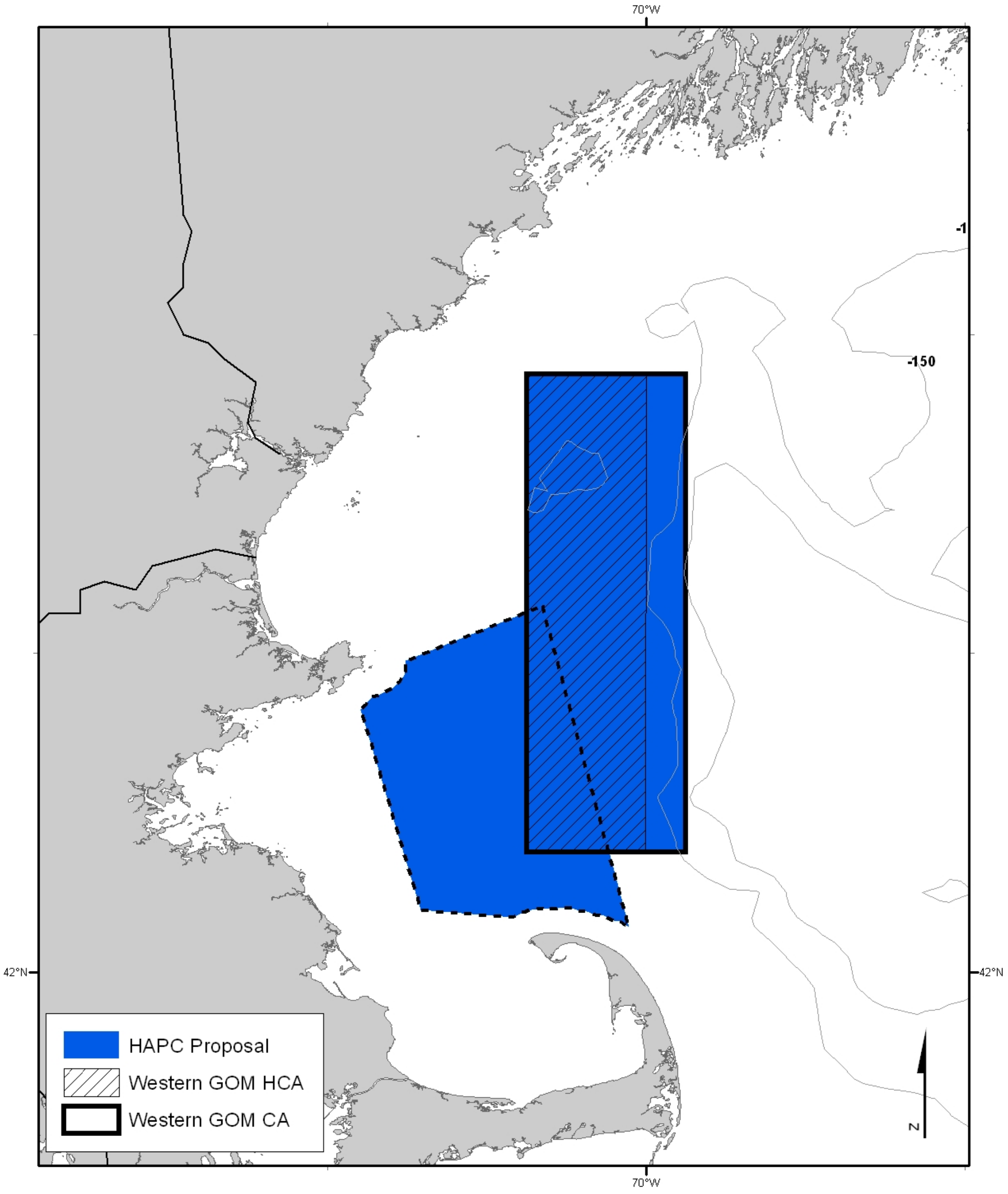
Map 24. Alternative 6A: Jeffrey's Ledge / Stellwagen Bank Alternative



Map 25. Alternative 6B: Jeffrey's Ledge / Stellwagen Bank Alternative



Map 26. Alternative 6C: Jeffrey's Ledge / Stellwagen Bank Alternative



3.1.7 Alternative7: Inshore Juvenile Cod

Overview

Based on the information presented on juvenile Atlantic cod and the inshore areas of the Gulf of Maine, coastal juvenile cod HAPC designation is recommended on the criteria of ecological function and sensitivity to induced environmental degradation. An HAPC designation for the nearshore Gulf of Maine could assist in the enhancement of Atlantic cod and other groundfish species. In 1999, the Council voted to approve this alternative and include it in the next appropriate fishery management plan vehicle. Since that time, the Habitat Plan Development Team has advised the Habitat Committee, based on the supporting information, that the Alternative should be expanded to include two options for public comment:

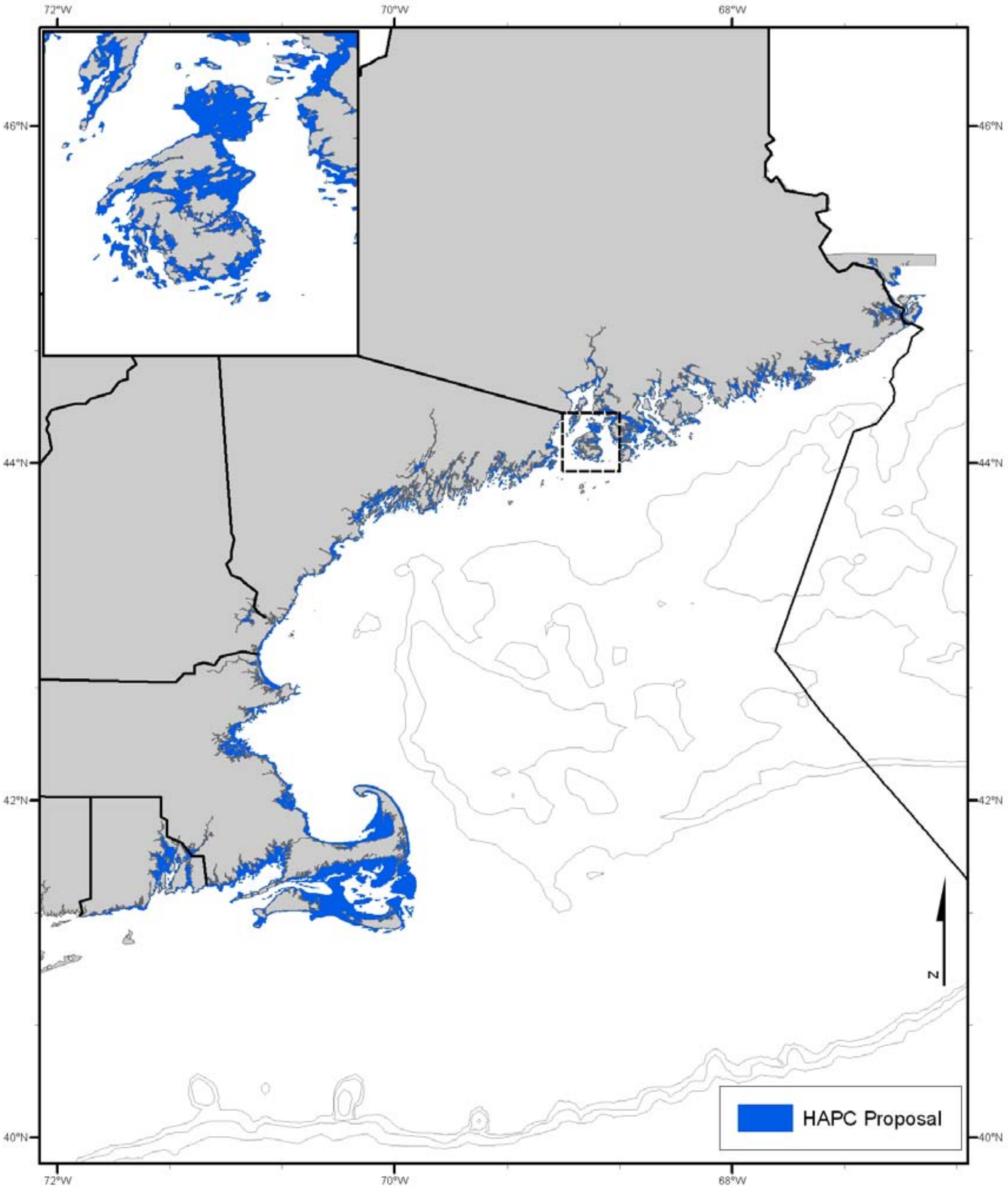
Option A: 0-10 meters (MLLW)

Option B: 0-20 meters (MLLW)

The most practical approach for delineating an HAPC for settled age-0 cod is to circumscribe the reported center of distribution for this life stage throughout the range of the stock. The information available suggests that the HAPC should be from the low tide line to a depth of 10 m (33') MLLW (Option A) or alternatively from the low tide line to a depth of 20 m (33') MLLW (Option B) from eastern Maine to the Rhode Island/Connecticut border. This narrow depth range describes critical habitat from settlement through the first autumn of life and overlaps seasonal habitat of age-1 juvenile cod. It also bounds the critical nursery zone for early benthic stages of important juvenile habitat for some other groundfish.

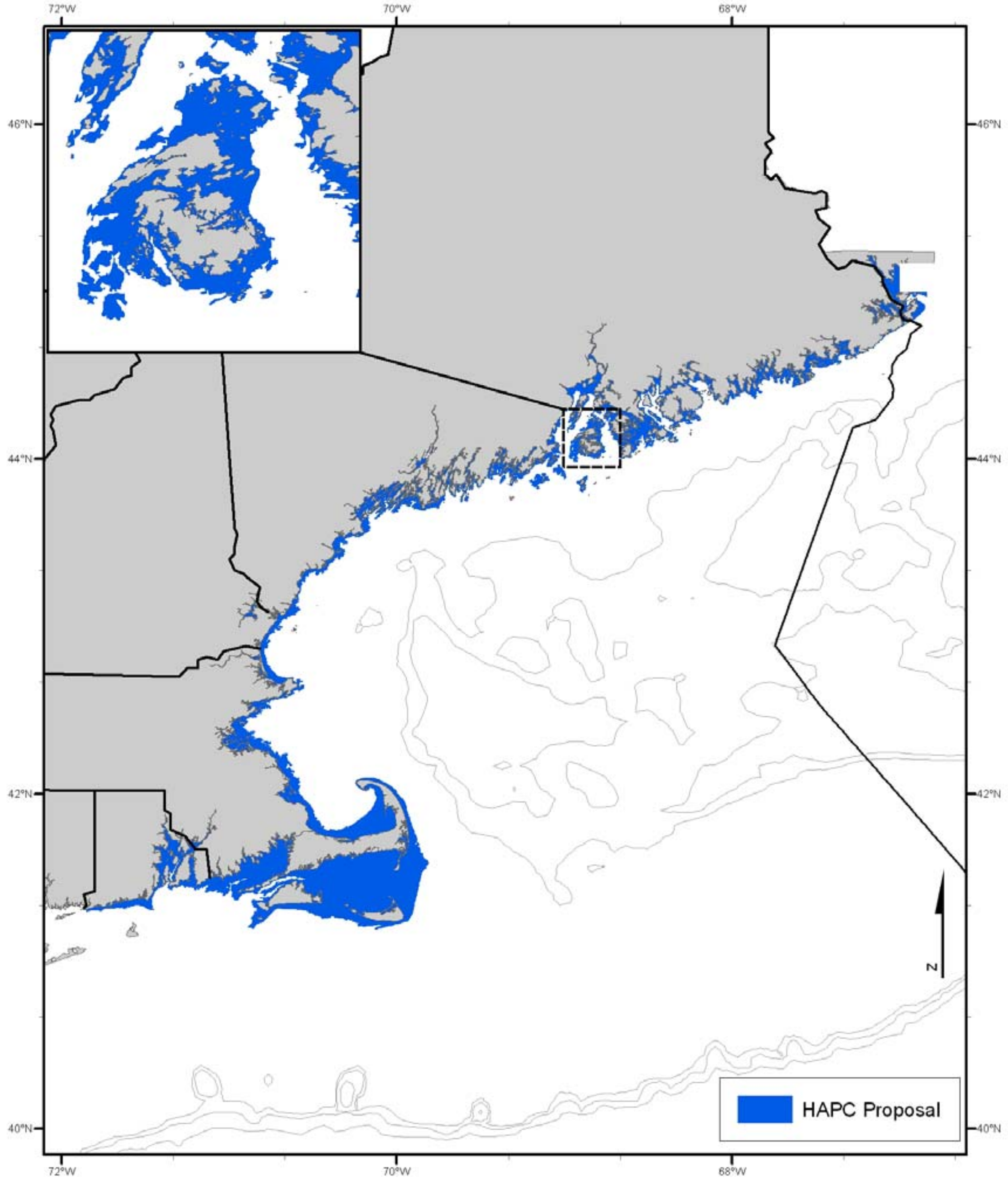
3.1.7.1 Alternative 7A: Inshore Juvenile Cod (0-10m depth contour)

Map 27. Alternative 7A: Inshore Juvenile Cod HAPC Alternative (0 - 10m depth contour)



3.1.7.2 Alternative 7B: Inshore Juvenile Cod (0-20m depth contour)

Map 28. Alternative 7B: Inshore Juvenile Cod HAPC (0-20m depth contour)



Recent Research

During the late 1980's, Atlantic cod inhabiting the waters off southern Labrador and eastern Newfoundland (viz. northern cod stock) underwent a dramatic decline in biomass, with the result that the famous Grand Bank fishery collapsed in 1992. This led to a fishing moratorium as well as an economic and ecological disaster (Hutchings 1996; Myers, et al. 1996). It also triggered unprecedented research at federal fisheries laboratories and universities in eastern Canada under the auspices of the Government of Canada's Northern Cod Science Program and the government / industry-funded Ocean Production Enhancement Network program. In total, there were 58 study initiatives and projects covering a broad suite of research costing about $48 million from 1990-95 (Campbell 1997).

The following description of research results from Canada and other countries deals with life history and behavioral ecology of newly settled juvenile cod, particularly post-settlement events relating to habitat that may ultimately affect recruitment strength. Studies have focused on laboratory observation experiments as well as field capture efforts utilizing active sampling equipment, SCUBA and submersible vehicles for *in situ* observations, and seabed classification techniques for acoustically classifying juvenile habitat. Nearly three dozen scientific papers relating to this subject have been published in recent years. The information is directly applicable to coastal nursery areas in the Gulf of Maine, the inference being that knowledge gained from such studies should be used for more risk-adverse habitat management.

Juvenile Cod Community & Interactions - Research Results

Pelagic Juvenile Settlement

Post-larval pelagic juveniles are transported by prevailing currents to shallow waters off eastern Newfoundland beginning in May and may continue arriving in periodic pulses as late as December (Methven and Bajdik 1994; Grant and Brown 1998). Their length upon settlement is 25-45 mm (Pinsent and Methven 1997). In southwest Nova Scotia, pelagic juveniles arrive inshore slightly larger (≈40-50 mm) in May (Tupper and Boutilier 1995a and 1995b), whereas influxes of larvae begin earlier in Massachusetts waters two to three months after hatching (Bigelow and Schroeder 1953). On Georges Bank, cod settle out in July at 40-60 mm, and those reaching rough and cobble bottom may experience reduced predation risk. This particular habitat may be an important demographic bottleneck to benthic recruitment on Georges Bank (Lough et al. 1989).

Pelagic juveniles exhibit no preference for habitat types at settlement, and they occupy rock reef, cobble, eelgrass (*Zostera marina*) beds, and sand bottom (Tupper and Boutilier 1995b). Tupper and Boutilier (1995b) assumed that settling also occurred on macroalgae habitat, as noted by Keats et al. (1987) off eastern Newfoundland, however, algal stands were scarce in the St. Margaret's Bay, Nova Scotia, study area due to subtidal grazing by sea urchins (*Strongylocentrotus drobachiensis*). Urchins commonly leave a partially denuded or "barren" zone along nearshore (≈2-12 m below MLW) sections of the maritime provinces and Gulf of Maine.

Age-0 Movements and Diel Feeding

Shallow water depths (<5 m) and a strong attraction to features on most substratums, except sand, afford settled juveniles an environment conducive to growth and survival (Tupper and Boutilier 1995a; Grant and Brown 1998b). A similar attraction to structure, particularly eelgrass and kelp, by age-0 cod was found in shallow waters (< 10 m) along the Maine mid coast in 2000 (Lazzari et al. 2003). The shallowness appears to ecologically segregate the 0-group cod from older age-groups at least during daylight (Tupper and Boutilier 1995a; Fraser et al. 1996; Gotceitas et al. 1997; Grant and Brown 1998a and 1998b). Age-0 cod maintain a strict diurnal foraging cycle, school (or shoal) feeding on zooplankton in a tide-related pattern during the day, and remain near protective bottom habitat which they readily seek when threatened (Gotceitas and Brown 1993; Gotceitas et al. 1995; Grant and Brown 1998a). The mottled coloring of young juveniles effectively conceals them in a pebble-gravel environment (Lough et al. 1989; Gregory and Anderson 1997). In contrast, pelagic juveniles on Georges Bank maintain a nocturnal feeding pattern (Perry and Neilson 1988). Age-0 cod cease feeding in surface waters and disperse to the substratum at night (Grant and Brown 1998b) where they are less active to reduce interactions with potential predators (Grant and Brown 1998a). The diel change in vertical distribution and activity of 0-group cod coincides with a nocturnal shoreward movement and foraging by older (age-1-3) conspecifics (Bosgstad et al. 1994; Gotceitas et al. 1997; Grant and Brown 1998a). Intercohort cannibalism is common. The occurrence of age-0 cod in very shallow water (<1.2 m) at night (Methven and Bajkik 1994) has also been interpreted as possibly an evasive response to predation risk (Grant and Brown 1998a).

Influence of Habitat Structure and Predation on Age-0 Demography

Tupper and Boutilier (1995b) found that the spatial pattern of settlement was altered by post-settlement mortality in St. Margaret's Bay, Nova Scotia. Age-0 survival was positively correlated with an index of rugosity, a measure of actual bottom surface or complexity. Capture success by fish predators (in this case, three species of Cottidae during a diurnal field study) was inversely related to the index of rugosity. As a result, higher densities of age-0 cod were found in cobble and rock reef habitats than in eelgrass. However, the rugosity index could not account for the complexity of surface area that eelgrass offered. Higher survival in sites of cobble and rock reef was attributed to increased shelter that the more structurally complex habitats afforded coupled with decreased predator efficiency (Keats et al. 1987; Lough et al. 1989; Tupper and Boutilier 1995b; Gotceitas et al. 1997; Grant and Brown 1998a and 1998b).

Tupper and Boutilier's (1995b) and Grant and Brown's (1998a) *in situ* studies confirmed earlier and subsequent laboratory experiments on substrate preference and predator efficiency. Clearly, the presence of conspecifics may influence the distribution and food intake of age-0 cod in the wild. Both age-0 and 1 cod preferred finer grained substrate in absence of a predator, but when in the presence of an age 3 conspecific, young-of-the-year and age-1 either avoided the predator or selected the coarser substrate (cobble vs. gravel) where they hid in interstitial spaces (Gotceitas and Brown 1993; Gotceitas et al. 1995; Fraser et al. 1996). Age-0 avoided the yearling conspecific resulting in a significant increase in use of gravel and cobble confirming the level of habitat segregation noted in the wild (Fraser et al. 1996). Also, age-0 cod avoided kelp (*Laminaria*) except when exposed to an actively foraging predator and cobble was unavailable. In this situation, kelp significantly reduced predation risk (Gotceitas et al. 1995). Both field and laboratory studies indicate that the association with coarse substrates, when coupled with behavior patterns that reduce predation risk, give young cod competitive advantage in avoiding detection or capture.

Eelgrass Habitat and Abiotic Factors

The presence of eelgrass beds or meadows appears to be a very important factor influencing the distribution of age-0 cod throughout the Canadian Maritime Provinces (Tupper and Boutilier 1995a; Gotceitas et al. 1997; Grant and Brown 1998a, 1998b) and along the Maine coast (Lazzari et al. 2003). Grant and Brown (1998b) noted that cod were more highly concentrated in eelgrass beds with >65% submersed canopy coverage. Gotceitas et al. (1997) captured age-0 cod almost exclusively in eelgrass beds of Trinity Bay, Newfoundland, where their usage by 0-group cod was consistent spatially and temporally. The eelgrass sites most sheltered to natural physical disturbance produced the highest catches; lower catches occurred at the shallowest and least saline sites (10.4-19.5 ppt). Salinities were usually high (>25 ppt) at most Newfoundland study sites (Methven and Bajkik 1994). Age-0 tolerate much lower salinities as was observed in coastal waters of Wales and England where catches occurred from 20-31 ppt (Riley and Parnell 1984).

Post-settlement cod may respond to environmental gradients in addition to substrate structure and salinity. For example, high water clarity may be important for feeding (Horne and Campana 1989). Strong tidal currents may be beneficial for concentrating food in seagrass beds (Tupper and Boutilier 1995b; Grant and Brown 1998a). Water temperatures coinciding with age-0 collections in St. Margaret's Bay, Nova Scotia, ranged between 4-9°C from May to July (Tupper and Boutilier 1995b) while July to September temperatures in age-0 habitat of Trinity Bay, Newfoundland, were 12-16°C with a year-round range of 1.7-17.0°C (Methven and Bajdik 1994). Water temperature might displace 0-group and yearlings to slightly deeper waters south of Newfoundland, however (Methven and Schneider 1998).

Among-Habitat Variation in Age-0 Growth

Growth of settled age-0 cod appears to be temperature dependent (Tupper and Boutilier 1995a). Growth was most rapid in eelgrass beds, which may positively effect overwinter survival of demersal 0-group juveniles. Growth was slowest on sand bottoms; differences in growth between young inhabiting reef and cobble bottoms were not significant (Tupper and Boutilier 1995b). The growth advantage conferred by seagrass is related to the variety of microhabitats therein that support a diverse community of invertebrates (Orth et al 1984; Heck and Crowder 1991; Heck et al. 1995; Grant and Brown 1998a). Planktonic organisms may be passively concentrated by water currents and effectively retained within the eelgrass canopy. Also, invertebrates and fish may actively seek its confines even crossing predation-risky sand to reach isolated patches (Sogard 1992).

Small planktonic crustaceans, but mostly copepods, are preyed upon by young cod (Keats and Steele 1992; Grant and Brown 1998a). When mouth gape size is large enough, at a length of 6 to 10 cm, cod transition to predominately benthic prey (Keats et al. 1987; Lomond et al. 1998) which they then consume at dusk and dawn (Grant and Brown 1998a).

Among-Habitat Variation in Age-0 Survival

Eelgrass provides age-0 cod protection from predators (Tupper and Boutilier 1995; Gotceitas et al. 1997; Grant and Brown 1998b). In a laboratory experiment, eelgrass significantly increased the time required for an age 3 cod to capture 0-group cod and decreased the number captured. With a predator present, young cod either hid in cobble or in eelgrass when stem density was >720 stems/m2. Time to capture was highest and total prey taken was lowest in combinations with cobble or vegetation of 1,000 stem/m2 (Gotceitas et al. 1997). Results demonstrated that high plant density and/or biomass, whether eelgrass or macrophytic algae (Isaksson et al. 1994), means reduced predation risk just as does use of certain substrates. Moreover, there may be a trade-off between nutritional gain and enhanced predation risk for age-0 cod utilizing eelgrass habitat (Tupper and Boutilier 1995).

Mark-recapture experiments indicate age-0 cod remain very localized, not moving more than several hundred meters in both eelgrass and no-eelgrass habitats (Grant and Brown 1998b). Those that settled earliest and were largest at settlement grew faster and defended a larger territory than later/ smaller settlers (Tupper and Boutilier 1995a), thus a competitive advantage in growth and survival may exist for the earliest pulse of post-larval juveniles over those settling later when temperatures and day length are reduced (Tupper and Boutilier 1995b).

Abundance in the seagrass sites of St. Margaret's Bay, Nova Scotia, was noted to decline after early June. This was attributed to predation rather than emigration because young were strongly site-attached and defended territory as they grew. Marked individuals were not found in areas surrounding the study site (Tupper and Boutilier 1995b). As the summer season advanced, a greater decline in abundance occurred in eelgrass beds and on sand than in structurally more complex reef and cobble habitat. Observing *in situ* young-of-the-year seeking shelter in rock crevices, empty scallop shells, and other debris within dense grass beds, Tupper and Boutilier (1995b) believed that cod out-grew eelgrass blades as suitable refuge.

Unable to compete for nonexistent shelter on sand habitat, age-0 cod school for protection (Tupper and Boutilier 1995a); however, the population density in these areas reached zero by late June (Tupper and Boutilier 1995b). Predation by three Cottids - sea raven (*Hemitripterus americanus*), longhorn sculpin (*Myoxocephalus octodecemspinosus*), and grubby (*Myoxocephalus aeneus*) - was most successful on sand and least successful on cobble and rock reef. Age-0 cod schooling over sand bottoms have low site fidelity which is disadvantageous to survival (Grant and Brown 1998a).

Young-of-the-year appear to lose site fidelity and disperse into deeper water during the December-January period (Tupper and Boutilier 1995a; Gregory and Anderson 1997) adopting winter behavior of reduced activity and food consumption (Brown et al. 1989). Still, some marked demersal juveniles remained localized in the shallowest (<1.2 m) sampling site in Trinity Bay, Newfoundland, throughout the winter even when ice was present (Grant and Brown 1998b). Age-0 and older juveniles are more adapted than adult cod to survive icy subzero water due to elevated plasma antifreeze levels in their blood (Goddard et al. 1992).

Age-1 and Older Juvenile Habitat and Movements

Age-1 juveniles are found during day and night in shallow inshore waters, including locations with moderate to high wave exposure (Keats 1990). Older juveniles are generally distributed farther away from shore than 0-group and 1-group cod and at depths >25 m. Age-1 associate to a greater degree with rocky substrate and fleshy macroalgae or bottom dominated by sea urchins and coralline algae (Keats et al. 1987; Keats 1990; Gotceitas et al. 1997). The association with a macroalgal canopy seems to be more one of refuge from predators than feeding purposes (Keats et al. 1987; Gotceitas et al. 1995; Gotceitas et al. 1997). They congregate in small groups near boulders and in large crevices. In Newfoundland bays, age-1 cod have been collected within a slightly narrower temperature range, 1-16°C, than demersal 0-group fish (-1.7-17°C) (Methven and Bajdik 1994).

At dusk during summer and autumn seasons, age-1 and older juveniles move shoreward into warmer water feeding areas where the young-of-the-year cod are concentrated. The attracting stimulus appears to be the periodic influxes of early settled cod (Keats 1990; Clark and Green 1990; Methven and Bajkik 1994). Age-1 cod have usually been found feeding until dawn primarily on mysids and gammarid amphipods; however, when they become about three times larger than settled age-0 juveniles, they begin cannibalizing the demersal 0-group cod (Grant and Brown 1998a). By late fall, the earliest age-0 settlers may be large enough to begin intracohort cannibalism on the late settlers, as has been noted in waters of Iceland (Bogstad et al. 1994). When abundance of older juveniles is high, mortality may increase on young-of-the-year because of competition and predation from conspecifics (Grant and Brown 1998a).

Age-1 cod have also been observed feeding on plankton after moving inshore in spring (Keats et al. 1987) as well as resting near bottom in shallow water at night (Keats and Steele 1992). In the latter situation, age-1 were not feeding and analysis of stomach contents indicated daytime foraging on planktonic crustaceans leading the authors to speculate that post-transitional feeding on benthic invertebrates might be patchy in space and time. Where, when, and to some extent what yearlings eat is likely related to trade-offs between predation risk and food availability.

Juvenile cod may utilize the intertidal zone for feeding purposes although there is no mention of this in recent studies. Earlier, an underwater television camera mounted on a herding fence recorded 423 "young" Atlantic cod (no size given), and Atlantic tomcod (*Microgadus tomcod)*, which were sometimes indistinguishable from cod, as well as six, 30-40 cm (age 3 to 4) cod moving up and down a beach, either with or against tidal current, during daytime between June and October in Passamaquoddy Bay, New Brunswick (Tyler 1971). Of eight fish species observed undertaking these movements, the cod/ tomcod combination ranked third, behind only winter flounder (*Pseudopleuronectes amercianus*) and Atlantic herring (*Clupea harengus*) in their use of the intertidal zone.

Diel Differences in Abundance

Keats (1990) found one- and two-year-olds 16 times more abundant at night than during the day while making SCUBA transects at a depth of 5-10 m MLW. Methven and Bajdik (1994) were able to seine age-1 cod throughout the year but only at night in a cove of Trinity Bay, Newfoundland, whereas age-1 were caught both day and night by Grant and Brown (1998a) in a different cove of the same embayment. An explanation for the difference in catch of yearling cod between the two studies may be related to sampling techniques. The first study employed a 9 m seine pulled from a maximum depth of 1.2 m (no bridle). The second utilized a 30 m seine deployed by small boat 50 m from shore and pulled by towropes thereby encircling age-1 cod inhabiting a slightly greater depth range.

Researchers studying young cod recognized that gear avoidance occurred during daylight, but avoidance was secondary to diel activity in explaining abundance differences between day and night catches for both age-0 and the older juveniles (Methven and Bajdik 1994; Gibson et al. 1996; Methven and Schneider 1998; Grant and Brown 1998b). Abundance of age-1 peaked in the shore zone from August-November and again in April-June period, but was much reduced in winter (temperature <0°C) indicating withdrawal to deeper habitat. The offshore movement by young cod was also reported in Passamaquoddy Bay, Bay of Fundy (MacDonald et al. 1984).

Juvenile Winter Habitat and Activity

Juveniles inhabit progressively deeper water and associate with coarser substratum as they grow and mature, especially in winter (Keats et al. 1987). Age-1-4 cod were observed at 18 to 150 m from submersible vehicles during April (-1°C at 25-75m), Placenta Bay, Newfoundland (Gregory and Anderson 1997; Gregory et al. 1997). They found that 80% of two-to four-year-olds were associated with rock, boulders, and high bathymetric relief (cliffs) and often maintained fidelity to such features including crevices in rocks. They exhibited significant increases in swimming speed with increasing distance from structure. Yearling cod showed no such connection, 59% of those observed were primarily over gravel and low relief with the fish appearing to rely on cryptic patterns to remain undetected. Macroalgae was neither avoided or preferred by either group. Age-1 and ages 2-4 co-occurred laterally and vertically throughout the study area most abundantly at depths of 60-120 m. Juveniles did not appear to undertake a diel movement shoalward during the winter/ early spring season. However, onshore movements may be initiated during March and April after ice break-up and coincident with nearshore water temperature of ≈2-3°C. The same temperature prompts offshore movements in late autumn (Methven and Bajkik 1994).

Sonic tagged age 3 cod (28-33 cm) rested almost exclusively in rocky areas at night during winter (Clark and Green 1990). Between June and September, however, individuals were active nocturnally and wide ranging (>3 km/day), moving daily between deep (30 m) cold water, where they were inactive in rocky areas, to shallow (<15 m) sandy substratum where they were active at night in relatively small feeding areas (≈540-2,580 m^2). When the water column became isothermal in September, age 3 cod remained in the shallow water during daylight leading researchers to speculate that the switch from nocturnal to diurnal feeding might be an antipredator strategy, i.e., to avoid being cannibalized at night when adult cod are seasonally active in relatively shallow water. Other common predators of juvenile cod off Newfoundland are pollock (*Pollachius virens*) and shortfinned squid (*Illex illecebrosus*).

Spatial Depth Gradient of Juveniles

For three years following stock collapse, Methven and Schneider (1998) undertook extensive sampling of the Newfoundland coastal zone to a depth of 55 m and by a variety of gears. Finding consistent spatial and diel changes in catch across gears, they interpreted results as characteristic of cod distribution. Catch rate of age-0 cod was inversely related to depth each year, highest at night, and higher at 4-7 m, the center of 0-group distribution during autumn. There was a sharp decrease in catch rate at 20 m (Schneider et al. 1997). Demersal age-0 cod were found almost exclusively alongshore within the northeastern coastal bays of Newfoundland; yearlings extended further offshore and older juveniles were widely distributed on the continental shelf confirming an ontogenetic pattern of movement to deeper water with increasing size. Age-dependent distribution was also obvious from trawl station catches on survey transects extending from the coast to hundreds of kilometers offshore (Dalley and Anderson

1997). When the stock was more robust, demersal age-0 cod were distributed more widely onto the shelf.

The only coastal region of eastern Canada where the seasonal pattern of distribution for young cod appears to be different is the coastal portion of southern Gulf of St. Lawrence where water temperatures might be too warm during summer months (Hanson 1996). Fine scale distribution studies with trawls found that cod did not occupy water 2-12 m deep along shores of Prince Edward Island during summer. They were mostly absent from shallow waters (<20 m deep) in the Miramichi estuary and the contiguous Shediac Valley coastal shelf during any time of year. Yearlings and 2-year-olds, but not age-0 cod, were almost exclusively found in 15-35 m depths of the Gulf from June to early October before joining older age-groups in an extensive migration to deep (>100 m) offshore water for winter.

The spatial depth gradient of juvenile cod from all other areas of eastern Canada seems consistent with published information from the Northeast Atlantic. The depth of highest age-0 cod abundance using a beam trawl off the British Isles was 6 m (Riley and Parnell 1984). Greatest density of age-1 cod sampled with gill nets off Greenland was <20 m (Hansen and Lehmann 1986; Hovgard and Nygaard 1990). Acoustic surveys off the Norwegian coast showed most juveniles at depths <35 m and highest densities of demersal 0-group cod very close to rocky shores where the research vessel could not survey (Olsen and Soldal 1989).

Density-dependent Habitat Use and Mortality

Contraction or expansion of geographic range with decreasing or increasing population size has been observed in a number of cod stocks including the Labrador-East Newfoundland complex and southern Gulf of St. Lawrence stock. In the latter region, the area occupied by age groups 3-8+ cod increased as abundance increased (Swain and Wade 1993). In comparison to the older cod, age 3 were more spatially restricted at low population size, their range expanded more slowly as abundance increased, and changes in relative density among parts of the Gulf were smaller between years of low- and high-abundance. Younger juveniles were thought to experience less severe competitive pressures for food or wider variation in habitat quality than the older age-groups.

A behavioral theory applied to explain the pattern of geographic distribution is density-dependent habitat use. This hypothesis was applied to young cod in coastal habitats (Olsen and Soldal 1989) where catches of post-settlement juveniles showed a high degree of small-scale spatial consistency regardless of cohort size. In years of high year-class abundance, density increases to an upper limit in the most suitable habitat and as the fitness of individuals occupying the prime sites declines due to intraspecific competition, diffusion to and use of suboptimal habitat expands. Accordingly, at low population size, individuals occupy habitat with high basic foraging and protective suitability.

The theory was tested for the Labrador-East Newfoundland stock complex for which contraction has been confirmed for adult cod at low stock size (Taggart et al. 1994; Atkinson et al. 1997). Catches of age-groups 0-2 were analyzed from 1959-64 and 1992-94 at a series of fixed sampling sites extending over 1,500 miles of Newfoundland coastline (Schneider et al. 1997). In years of low cohort size, contraction did not occur in coastal habitats, i.e., density of juvenile cod was independent of area within the occupied <20 m depth range. They noted that sampling sites with high densities in some years had low densities in years of high abundance, an observation inconsistent with spillover theory in good years.

In support of density-dependent theory, high post-settlement densities of age-0 cod were found in eelgrass beds of Trinity Bay, Newfoundland, during 1994 and 1995, years of good and bad year-classes, respectively; however, a significant increase in abundance in less suitable no-eelgrass habitat was noted in 1994 when settlement strength was high (Grant and Brown 1998a). The high 1994 densities in less-utilized no-eelgrass habitat during a year of high abundance would be consistent with the hypothesis of density-dependent habitat use or selection. The researchers acknowledged that their observations were on a small temporal and spatial scale. Re-analysis of the fixed sampling site juvenile catch data from Newfoundland showed a stronger recruitment signal from a small number of sites visited frequently than the entire set of sites (Ings et al. 1997). The 1994 year class was ranked significantly stronger than the three previous year-classes following stock collapse in a broad-scale study (Anderson and Dalley 1997). On the other hand, there was no evidence of fewer settled 0-group juveniles anywhere along the coast in 1995 relative to the 1992-94 year-classes (Smedbol et al. 1998).

For a number of cod stocks, variability in year class strength is usually determined in the larval stage and attenuated by density-dependent juvenile mortality (Myers and Cadigan 1993a). Biological processes that may result in density-dependent mortality would include: (1) competition for food with mortality resulting from increased predation or starvation; (2) intercohort cannibalism; (3) predators switching to abundant year-classes; and (4) a circumscribed area of prime juvenile habitat with those settling surviving while others do not, resulting in a upper limit to the number of survivors regardless of egg/larval production. This mechanism could involve food limitation and/or increased predation risk outside a prime nursery area. It presumes mechanisms maintaining a relatively constant density such as territorial behavior or some other form of density-dependent habitat utilization.

Notwithstanding the study by Schneider et al. (1997), many of the research results discovered and re-confirmed by scientists undertaking the studies summarized herein, describe or infer habitat mediated density-dependent mortality rates. These mechanisms systematically affect cod survival rates from the post-settlement pelagic stage well into the demersal juvenile stage. Annual variation in survival rates on these life stages may be more important in affecting year class size than survival in pre-settlement stages (Sissenwine 1984). This suggests that the nearshore bottom habitat may become a potential bottleneck to year-class size particularly in areas where the availability of the most suitable habitat might be low.

Summary of Research

In shallow (< 5 m) coastal areas of eastern Canada, pelagic juvenile cod settle onto various subtidal habitats in several periodic pulses beginning in May. Age -0 cod settle in shallow waters (< 10m) of the Maine mid coast beginning in April. Space use is highly localized and primarily focused on the need to acquire food and avoid predators. Relative to fulfilling both needs, activity periods, substrate choices, and interactions with members of same species and others are critical. Diurnal feeding in inter-cohort schools aids location of patchily distributed plankton and provides protection against predators. Site fidelity and nightly concealment in all habitats, except sand, minimizes interactions with cannibalistic age-1 cod that move shoalward at dusk to feed. The spatial pattern of age-0 cod distribution is altered by post-settlement mortality such that abundance among bottom habitats matches substratum complexity: cobble/gravel ≥ rock reef > eelgrass ≥ macroalgae > sand. Of bottom habitats studied, eelgrass confers a significant advantage in growth to age-0 cod. Significantly reduced predation risk also occurs if eelgrass stems are above a threshold density and/or they are associated with cobble bottom. Eelgrass meadows are highly utilized as nursery habitat both spatially and temporally through at least mid-summer. The transition to a demersal existence occurs at a length of 6-10 cm and is marked by a switch to benthic prey foraged at dawn and dusk. The distribution of age-0 cod in autumn is centered at depths of 4-7 m MLW with a sharp drop off at 20 m. In late autumn/ early winter, age-0 lose site fidelity and disperse to deeper water where they congregate primarily over gravel and low relief cover.

Older juveniles inhabit progressively deeper water and associate with coarser, hard-bottom features as they grow. Seasonal inshore movements are usually associated with nocturnal feeding. Age-1 cod, while co-existing in all but the shallowest depths with young-of-the-year, are many times more abundant in the shore zone at night than during the day apparently attracted there by the presence of periodic influxes of post-larval pelagic juvenile cod.

Competitive advantage accrues to the largest and earliest settling juveniles especially those finding coarse substratum with vegetative cover. Those less favored must disperse from feeding patches more often thereby accepting a lower rate of food intake in order to avoid detection and capture. As Tupper and Boutilier (1995b) hypothesized: "one habitat might supply the population with a greater number of smaller recruits, each with a somewhat lesser chance of survival, while another habitat supplies fewer, larger recruits, each with a relatively high chance of survival".

The trade-offs between habitat use and frequencies of feeding in the face of predation risk are processes consistent with density-dependent habitat use and mortality. Although empirical evidence of density-dependent usage off Newfoundland is contradictory, stock size/recruitment may not yet be large enough following the northern cod stock collapse to induce significant density-dependent effects on a large spatial scale. Nevertheless, behavioral research details ways age-0 juveniles respond to spatial heterogeneity, the consequences for fitness through utilization of resources, and the intra-specific competitive effects which emphasizes the importance of habitat availability and quality in determining recruitment success.

References

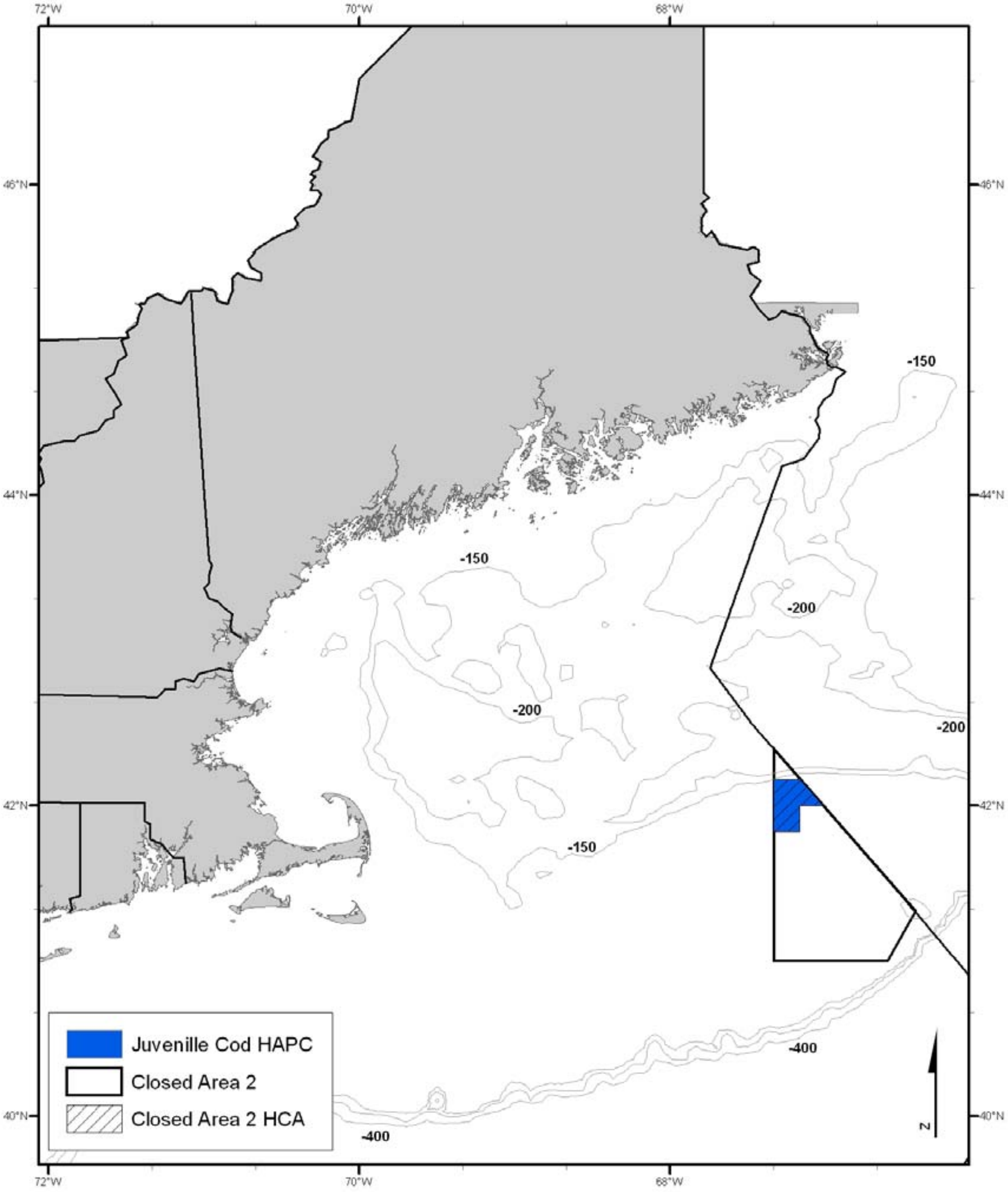
INSERT REFERENCES HERE ???

3.1.8 Alternative 8: Elimination of Status Quo HAPCs

This alternative provides a mechanism for the Council to remove or "un-designate" the current HAPCs that are designated on George's Bank (Map 29) and in Maine (Map 30).

3.1.8.1 Alternative 8A: Eliminate Cod Status Quo HAPC

Map 29. Alternative 8A: Cod Status Quo HAPC



3.1.8.2 Alternative 8B: Eliminate Atlantic Salmon Status Quo HAPC

Map 30. Alternative 8B: Atlantic Salmon Status Quo HAPC