Appendix K
Research and Monitoring Approaches for Evaluation of EFH Fishing Impact Minimization Alternatives

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ACRONYMS AND ABBREVIATIONS

AI	Aleutian Islands
Council	North Pacific Fishery Management Council
EA	environmental assessment
EBS	Eastern Bering Sea
EFH	essential fish habitat
EIS	environmental impact statement
FMP	fishery management plan
GOA	Gulf of Alaska
NMFS	National Marine Fisheries Service

In February 2003, the North Pacific Fishery Management Council (Council) directed that each essential fish habitat (EFH) fishing impact minimization alternative within the EFH environmental impact statement (EIS) include a research and monitoring component to help determine the efficacy of that alternative, should it be implemented, and to determine, to the extent practical, the effects of fishing on habitat. As directed by the Council, each alternative shall contain specific language as to the intent and objectives of its research component linked with the goals of the alternative. The final hypothesis-driven research design shall be developed when the preferred alternative is selected in a subsequent process that will include public and stakeholder input. All alternatives should contain benthic mapping to improve future management and meet research goals. In the proposed research components, research designers will attempt to map all closed and open areas as square blocks rather than as irregular shapes. The Council also noted that it supports full funding of the essential fish habitat research.

Based on the above direction from the Council, this appendix to the EIS describes the overall goals and objectives for research and monitoring for each EFH fishing impact minimization alternative. It does not discuss different research areas and/or specific experimental designs for each alternative. However, to the extent that goals and objectives for research and monitoring may differ based on the type of alternative being considered (e.g., the goals for evaluating a rotational management scheme might differ from the goals for evaluating permanent closures), this appendix to the EIS discusses those differences. The following sections describe preliminary research and monitoring approaches for each of the alternatives.

Once the Council selects a preferred alternative to minimize adverse effects of fishing on EFH, the National Marine Fisheries Service (NMFS) and Council staff will begin developing the necessary analyses to implement research and monitoring. This subsequent process will develop a hypothesis-driven research design and will include public and Council input to help select research areas. An environmental assessment (EA) will be used to evaluate options for the research and monitoring, and it will be accompanied by a Regulatory Impact Review and Regulatory Flexibility Act analysis of socioeconomic impacts. Implementation of the research and monitoring program will be contingent on the availability of sufficient funds.

K.1 Research Approach for EFH Fishing Impact Minimization Alternative 1

K.1.1 Objectives

No additional measures would be taken at this time to minimize the effects of fishing on EFH.

K.1.2 General Research Questions

Consideration of ecosystem health and the effect of fishing on EFH should focus on whether adverse impacts alter structure, function, and/or rates of ecosystem processes. Scientific assessments should address whether fishing activities reduce habitat suitability for marine resources and, thus, affect sustainable harvest levels. In particular, habitat-mediated effects on spawning, breeding, feeding, growth, and shelter of fishery management plan (FMP) species should be examined. This is a two-stage process that requires identification of specific effects attributable to fishing activities and subsequent interpretation of these effects to determine the positive/negative ecological implications.

K.1.3 Research Activities

Three experimental approaches are applicable to these general research questions, and suitable research sites are generally available in the Bering Sea (EBS), Gulf of Alaska (GOA), and Aleutian Islands (AI) areas.

(1) Compare conditions in heavily fished and lightly fished/unfished areas that are close to each other and otherwise similar. This approach allows an assessment of the long-term (chronic) effects of fishing activity on physical features of the seabed, as well as effects on the structure and function of associated benthic invertebrate communities. High-quality fishing effort data are required to identify appropriate experimental sites, which may or may not straddle closed area boundaries. Replicated biological sampling with grabs, trawls, and underwater video or submersible observations is needed to characterize relevant population and community-level attributes in the disturbed and undisturbed sites. Attributes include biomass, numbers of individuals, body size, species richness, species diversity, and the physiological states of biostructure, prey, and resident FMP species. Acoustical surveys with multibeam, side scan, or single-beam devices, coupled with grab and video groundtruthing, would be the basis for comparison of physical features such as sediment texture and bedforms. Very few sites are available under the status quo where heavily fished and lightly/unfished areas are located in close proximity over similar habitat. McConnaughey (2000) found significantly greater abundance and diversity and a less patchy distribution of sedentary benthic macrofauna within the Bristol Bay Crab and Halibut Protection Zone, compared to outside the zone. The Bristol Bay Crab and Halibut Protection Zone had been unfished since 1959. Stone (in press) did studies around the Kodiak crab closures (established ~1987), but found only subtle differences between the closed and the open areas.

(2) Compare conditions before and after experimental fishing to identify short-term (acute) effects on the benthos. If unfished controls are incorporated in the experimental design, recovery after disturbance(s) can also be examined with continued sampling. Replication with multiple (paired) sites is required to avoid spurious outcomes. These sites should have limited or, preferably, no prior fishing disturbance history in order to obtain a full measure of acute effects. Otherwise, longer-lived individuals or species will be under-represented in the samples, thereby biasing results. In addition to sampling methods and gear types described in (1) above, effective contrasts of conditions before and after fishing require highly accurate positioning of fishing and sampling gear within the disturbed (experimentally fished) and undisturbed (control) sites, especially when destructive sampling methods (e.g., research trawls) are used.

(3) Determine rates of disturbance with repetitive fishing of specific grounds. Incremental and cumulative catch rates can be used to measure the rates of depletion of benthic fauna, changes in community structure, and alteration of seabed properties as a function of fishing intensity. Similar to (2) above, these sites should have limited or, preferably, no prior fishing disturbance history in order to obtain a full measure of effects. Once again, careful positioning of fishing and sampling gear is required for meaningful results.

K.1.4 Research Time Frame

The time frame for completion of studies in the Alaska Region under Alternative 1 cannot be estimated until more systematic methods are developed and implemented, and the overall level of research effort increases. A preliminary research plan for studying the effects of fishing activities on benthic habitat in the Alaska Region was developed in 1999. Three classes of projects were identified: 1) effects of specific gear on specific habitat, 2) linkage of fishing-induced disturbance to population dynamics of commercial and non-commercial species, and 3) mitigation of effects through gear design. Application of research findings to date is generally limited by their experimental designs to the specific localities studied. Similarly, the geographic scope of efforts to map the distribution of distinct benthic habitat types has been limited. At the present rates, several hundred years may be required to gain a comprehensive understanding of fishing gear effects on specific benthic habitats and the distribution of these habitats in the EBS, GOA, and the AI.

K.2 Research Approach for EFH Fishing Impact Minimization Alternative 2

K.2.1 Objectives

Reduce impacts. Restrict the higher impact trawl fisheries (compared to other fishing gear) from a portion of the GOA slope, thus encouraging a switch to fixed gear and pelagic trawls.

Benthic habitat recovery. Allow benthic habitat within these areas to recover or remain relatively undisturbed.

K.2.2 Research Questions

Reduce impacts. Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gears in the closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types?

Benthic habitat recovery. Did the habitat within these areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas still fished without EFH protection?

K.2.3 Research Activities

Reduce impacts. Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. Lack of recent fishing effort in and adjacent to the proposed closure areas would indicate that the chosen closure areas would have little efficacy in achieving the objective of reducing impact. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. The relative effects of bottom trawl and alternative gears and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species with each gear. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on benthic habitat.

Benthic habitat recovery. Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Because the selected closure areas have received little fishing effort in recent years, determining whether any changes constitute recovery from fishing or just natural variability/shifts requires comparisons with both an area that is undisturbed by fishing and otherwise comparable, and an area that has been recently disturbed by fishing and is otherwise comparable. To ensure comparability, the areas should be close to each other. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance. Replication in these studies will depend on the essential similarity, or lack thereof, of the 11 designated areas.

Replicated biological sampling with grabs, trawls, and underwater ROV or submersible observations is needed to characterize relevant population and community-level attributes in the disturbed and undisturbed sites, such as biomass, numbers of individuals, body size, species richness, species diversity, and the physiological states of biostructure, prey, and resident FMP species. Acoustical surveys with multibeam, side scan, or single-beam devices, coupled with grab and video groundtruthing, would be the basis for comparison of physical features such as sediment texture and bedforms.

K.2.4 Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period of time if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner.

K.3 Research Approach for EFH Fishing Impact Minimization Alternative 3

K.3.1 Objectives

Reduce impacts. Restrict the higher impact trawl fisheries (compared to other fishing gear) from a portion of the GOA slope, thus encouraging a switch to fixed gear and pelagic trawls.

Benthic habitat recovery. Allow benthic habitat within these areas to recover or remain relatively undisturbed.

K.3.2 Research Questions

Reduce impacts. Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gear types in the closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types?

Benthic habitat recovery. Did the habitat within these areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas that are still fished without EFH protection?

K.3.3 Research Activities

Reduce impacts. Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. Lack of recent fishing effort in and adjacent to the proposed closure areas would indicate the chosen closure areas would have little efficacy in achieving the objective of reducing impact. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. The relative effects of bottom trawl and alternative gear types and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. The basis for comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species with each gear. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on benthic habitat.

Benthic habitat recovery. Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Because the selected closure areas have received little fishing effort in recent years, determining whether any changes constitute recovery from fishing or just natural variability/shifts requires comparison with both an area that is undisturbed by fishing and is otherwise comparable, and an area that has been recently disturbed by fishing and is otherwise comparable. To ensure comparability, the areas should be close to each other. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance. This alternative is primarily distinguished from Alternative 2 by the geographic extent of closures that would occur. Replication in these studies will depend on the existence and identification of similar experimental areas within this larger 200 to 1,000 m closure.

Replicated biological sampling with grabs, trawls, and underwater ROV or submersible observations is needed to characterize relevant population, and community-level attributes in the disturbed and undisturbed sites, such as biomass, numbers of individuals, body size, species richness, species diversity, and the physiological states of biostructure, prey, and resident FMP species. Acoustical surveys with multibeam, side-scan, or single-beam devices, coupled with grab and video groundtruthing, would be the basis for comparison of physical features such as sediment texture and bedforms.

K.3.4 Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period of time if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner.

K.4 Research Approach for EFH Fishing Impact Minimization Alternative 4

K.4.1 Objectives

Bering Sea. (1) Limit fishing vessels to areas historically fished and prevent them from expanding into new areas. (2) Reduce the amount of fishing gear contact with the bottom through the use of discs and bobbins to lift up the net and sweeps. (3) Allow a portion of the habitat to recover to an "unaffected by bottom trawl fishing" status by using rotating closures.

Aleutian Islands. (1) Allow a portion of the benthic habitat to recover from the effects of bottom trawling.

Gulf of Alaska. (1) Restrict the higher impact trawl fisheries from a portion of the slope, thus encouraging a switch to fixed gear and pelagic trawls. (2) Allow benthic habitat within these areas to recover or remain relatively undisturbed.

K.4.2 Research Questions

Reduce impacts. Does the closure effectively restrict higher impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gear types in the closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear/footrope designs?

Benthic habitat recovery. Did the habitat within these areas recover or remain unfished because of these closures? Are 10-year closures in 25 percent of closed areas sufficient and optimum for complete recovery of disturbed benthic habitat? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas still fished without EFH protection?

K.4.3 Research Activities

Reduce impacts. Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. If recent fishing effort declined or ceased in and next to proposed closure areas, the areas would have little efficacy in achieving the objective of reducing impact. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. Effects of displaced fishing effort would have to be considered. The relative effects of bottom trawl and alternative gear/footrope designs and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear. The period of closures (10 years) and the instantaneous closed area fraction (25 percent) for rotating closures in the EBS should be evaluated experimentally with respect to severity of cumulative impacts over the period of active fishing and the relationship of the disturbance pattern to recruitment/recovery rates. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on benthic habitat.

Benthic habitat recovery. Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable. A reference site would have to be established and remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance.

K.4.4 Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period of time if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner. Ideally several complete 40-year closure cycles would be used to evaluate the efficacy of the strategy.

K.5 Research Approach for EFH Fishing Impact Minimization Alternative 5

K.5.1 Objectives

Bering Sea. (1) Limit fishing vessels to areas historically fished and prevent them from expanding into new areas. (2) Reduce the amount of fishing gear contact with the bottom through the use of discs and bobbins to lift up the net and sweeps. (3) Allow a portion of the habitat to recover to an "unaffected by bottom trawl fishing" status through the use of rotating closures.

Aleutian Islands. (1) Allow a portion of the benthic habitat to recover from the effects of bottom trawling.

Gulf of Alaska. (1) Restrict the higher impact trawl fisheries from a portion of the slope, thus encouraging a switch to fixed gear and pelagic trawls. (2) Allow benthic habitat within these areas to recover to a near "unaffected by fishing" condition.

K.5.2 Research Questions

Reduce impacts. Is bottom trawling kept from expanding into unfished areas of the EBS? Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gear types in the GOA closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear/footrope designs?

Benthic habitat recovery. Did the habitat within these areas recover or remain unfished because of these closures? Are 5-year closures in 33 1/3 percent of closed areas sufficient and optimum for complete recovery of disturbed benthic habitat? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas still fished without EFH protection?

K.5.3 Research Activities

Reduce impacts. Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. The effects of displaced fishing effort would have to be considered. The relative effects of bottom trawl and alternative gear/footrope designs, and, thus, the efficacy of the measure, should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear. The period of closures (5-year) and the instantaneous closed area fraction (33 1/3 percent) for rotating closures in the EBS should be evaluated experimentally with respect to severity of cumulative impacts over the period of active fishing and the relationship of the disturbance pattern to recruitment/recovery rates. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on benthic habitat.

Benthic habitat recovery. Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural

variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance.

K.5.4 Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period of time if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner. Ideally several complete 15-year closure cycles would be used to evaluate the efficacy of the strategy.

K.6 Research Approach for EFH Fishing Impact Minimization Alternative 5B

K.6.1 Objectives

Reduce impacts. (1) Limit fishing vessels to areas historically fished and prevent them from expanding into new areas. 2) Avoid increased effort in areas that remain open. (3) Reduce the bycatch of benthic epifauna. (4) Increase monitoring for enforcement. (5) Improve estimation of invertebrate bycatch. (6) Establish a scientific research program.

Benthic habitat recovery. Allow recovery of habitat in a large area with relatively low historic effort.

K.6.2 Research Questions

Reduce impacts. Is bottom trawling kept from expanding into unfished areas of the EBS? Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gears in the GOA closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types? What are the research priorities? Are sponge and coral essential components of the habitat supporting FMP species?

Benthic habitat recovery. Did the habitat within these areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas that are still fished without EFH protection?

K.6.3 Research Activities

Reduce impacts. Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. Effects of displaced fishing effort would have to be considered. The relative effects of bottom trawl and alternative gear/footrope designs and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. The basis of comparison would be changes in the structure and function of benthic

communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on sponge and coral habitat.

Benthic habitat recovery. Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance.

K.6.4 Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period of time if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner.

K.7 Research Approach for EFH Fishing Impact Minimization Alternative 6

K.7.1 Objectives

Reduce impacts. In all regions, eliminate all effects of fishing on EFH in 20 percent of the area historically fished.

Benthic habitat recovery. Allow protected areas to fully recover to an "unaffected by fishing" condition.

K.7.2 Research Questions

Reduce impacts. Does the closure effectively restrict higher impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gears in the closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types?

Benthic habitat recovery. Did the habitat within these areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP fish?

K.7.3 Research Activities

Reduce impacts. Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. The relative effects of bottom trawl and alternative gears and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed,

after comparable harvests of target species are taken with each gear. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on benthic habitat.

Benthic habitat recovery. Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance. Replication in these studies will depend on the essential similarity, or lack thereof, of the designated areas.

K.7.4 Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period of time if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner.