NMFS SCIENCE CENTER REPORT IN RESPONSE TO COUNCIL REQUEST: "HAS AMENDMENT 19 WORKED?"

1. Objectives of this Report:

This document is intended to address the PFMC's request to provide a potential approach to evaluating the question of whether current essential fish habitat (EFH) designations are working as expected, including criteria for objective evaluation of the question.

Essential fish habitat boundaries for groundfish and a number of habitat areas of particular concern (HAPCs) were established in Amendment 19. The entire shelf and slope area was designated as EFH, but this designation alone does not provide any fishing restrictions. Also through Amendment 19, a number of areas were permanently closed to certain types of bottom contact gear to protect groundfish EFH – the Amendment 19 EFH Conservation Areas. Amendment 19 also included several fishing gear restrictions that are not area specific and recommendations for addressing non-fishing impacts. Together, these measures were designed to fulfill the requirements for EFH established by the Magnuson-Stevens Act. Note that a number of management activities, including the establishment of the spatial and temporal closures termed the Rockfish Conservation Area in 2002, were put in place prior to Amendment 19. We focus most of our discussion in this report on issues related to Amendment 19.

In Section 2 of this report, we provide a brief summary of the science available to address the five objectives articulated for Amendment 19 in the Record of Decision (NMFS 2006). We reference relevant figures, tables, or discussions for each objective in the Essential Fish Habitat Review Committee Phase 1 Report (EFH-P1, PFMC 2012); the NMFS Groundfish Essential Fish Habitat Synthesis Report (EFH-S, NMFS 2013a); the NMFS Groundfish Essential Fish Habitat Synthesis Report Appendix (EFH-SA, NMFS 2013b); and the Essential Fish Habitat Review Committee Phase 2 Report (EFH-P2, PFMC 2014). The research and information items described in Section 2 are not an exhaustive list or intended to replace or de-prioritize similar activities in the Council's record. Appendix B.5 to the Groundfish FMP, section 9 of EFH-P2, and the Council's 2013 Research and Data Needs document are therefore incorporated by reference.

In Section 3, we provide a long-term scientific perspective on methods to improve our understanding of the effects of management actions, such as restoration or protection of habitat, on fish populations. The NMFS Habitat Assessment Improvement Plan (HAIP; NMFS 2010) established a framework for conducting habitat assessments, and evaluated national science needs on a region-by-region basis to achieve greater levels of habitat assessment excellence. The HAIP drew from the example of the Pacific Fishery Management Council's 2005 Environmental Impact Statement on EFH designation and minimization of adverse impacts to the West Coast groundfishes that formed the basis for Amendment 19 (Copps et al. 2007). That assessment represented a compilation of information on the status of habitats important to groundfishes and the impact of fishing on those habitats.

The HAIP outlines the gaps in groundfish habitat science on the West Coast, identifies steps to improve habitat assessments, and includes estimated magnitude and extent of resources needed by both the Northwest and Southwest Fisheries Science Centers to adequately conduct assessments. As defined in the HAIP, habitat assessment is both the process and products associated with consolidating, analyzing, and reporting the best available information on habitat characteristics relative to the population dynamics of fishery species and other living marine resources (Figure 1). Indicators of the value and condition of marine habitats can be developed through a habitat assessment by investigating the relationships between habitat characteristics, the productivity of fish species, and the type and magnitude of various impacts. The ultimate goal of a habitat assessment is to support management decisions by providing information on how habitats contribute to species' productivity.

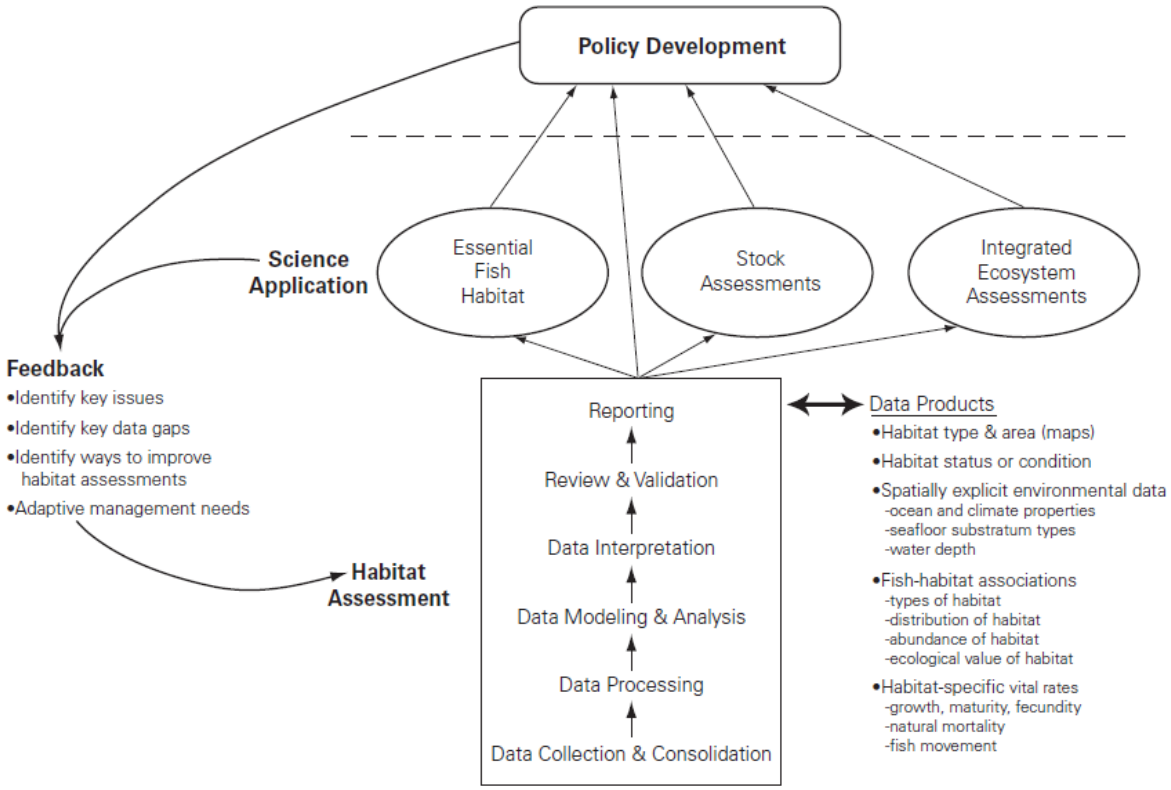

Figure 1. Flow diagram of the mechanics (development, application, and improvement through feedback) of a habitat assessment. Dotted line illustrates the distinct separation of science and policy development during the assessment process (from NMFS Habitat Assessment Improvement Plan [NMFS 2010]).

In Section 3, we draw attention to the framework highlighted in the NMFS HAIP, and then outline two paths for habitat research: 1) research avenues that can be pursued with available data and analysis techniques and that supplement discussions of future research, and 2) potential methods for integrating spatial management methods with new research to efficiently advance our understanding of habitat effects on fish populations. Neither of these sub-sections is meant to be an exhaustive discussion of potential research; rather, we point out avenues of research not specifically noted in the EFH-P1, EFH-S, EFH-SA, or EFH-P2.

2. Framework to Address the Council's Request

From the Record of Decision for Amendment 19 (NMFS 2006) fishery management measures (e.g., area closures, gear modifications) were designed to:

a) protect a diverse array of habitat types across latitude ranges and within the two known biogeographic zones that occur in the project area;
b) protect the full range of benthic habitat to account for each managed species;
c) prioritize pristine or sensitive habitats and the gear types most likely to have the highest impact;
d) distribute socioeconomic costs that would result from implementation of the alternative; and,
e) implement area closures for different gear types within different habitat types to foster comparative scientific research.

We address objectives *a* to *e* in turn:

a) Protect a diverse array of habitat types across latitude ranges and within the two known biogeographic zones that occur in the project area

At present, a variety of fishing gear restrictions and modifications protects a diversity of habitat types. The EFH Synthesis provides a series of visual and tabular summaries of the location and proportion of area associated with each restriction (see EFH-S pg. 15-38, EFH-SA pg. 16-38). These tables and figures summarize fishing restrictions by depth, biogeographic region, and bottom substrate type. Available information on biogenic habitat is not of sufficient extent and quality to describe fishing restrictions with respect to biogenic habitats.

From the information summarized in the Groundfish EFH Synthesis report we know[1]:

- Knowledge of physical habitat is non-uniform. Seabed habitat mapping has been conducted only over continental shelf and slope and inland seas, and coverage of those areas is very patchy across the West Coast. The abyssal plain and continental rise remain largely un-described for seabed type and extent.
- Knowledge of biogenic habitat is non-uniform. No systematic regional surveys of coral and sponge distribution and abundance have been conducted. A large majority of observations were made over the past two decades, during targeted studies on habitats associated with groundfish species or on habitats suspected to support coral and sponge communities.
- Hard seabed habitat is less abundant, or rare, in comparison to soft seabed, and the relative proportions of each type within depth strata are fairly consistent across biogeographic sub-regions (Figure 2).
- Approximately 10% of all habitats on the upper slope and shelf of the West Coast is included in ecologically important habitat closed areas (EFH conservation areas), and the bottom trawl closure seaward of 700 fm accounts for the majority of the conservation areas. Soft substrate on the slope and upper shelf proportionately less protected than hard substrate on the slope (Figure 3).
- On the continental shelf and upper slope, most areas where corals and sponges were present are outside EFH conservation closures. On the lower slope, the presence of corals

[1] Peer review of these and other conclusions in this document has not occurred and they are therefore subject to change.

and sponges largely occurred in areas protected from bottom trawling, although significant areas were also protected from all bottom-contact gear.

- Effort from federally observed groundfish fisheries is highest in the Northern region, and is heavily concentrated on the upper slope and shelf over soft habitats along the entire coast.
- Patterns of fishing effort have remained moderately stable over the previous decade, but have likely varied over longer periods; there has been some displacement of trawling activity seaward from conservation areas.
- EFH conservation areas protect some groundfish species from fishing more than others.

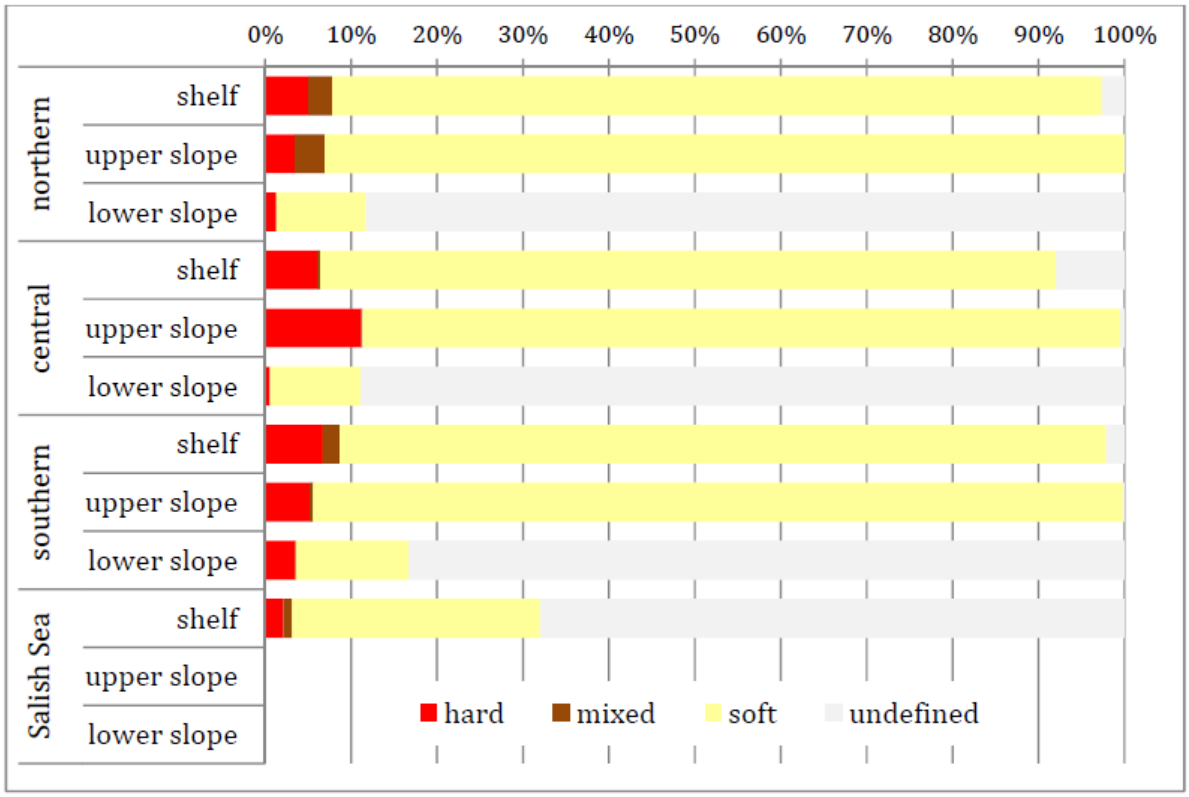

Figure 2. Relative distribution of seabed habitat types by depth zones in four biogeographic subregions (from NMFS Groundfish EFH Synthesis Report [NMFS 2013a]).

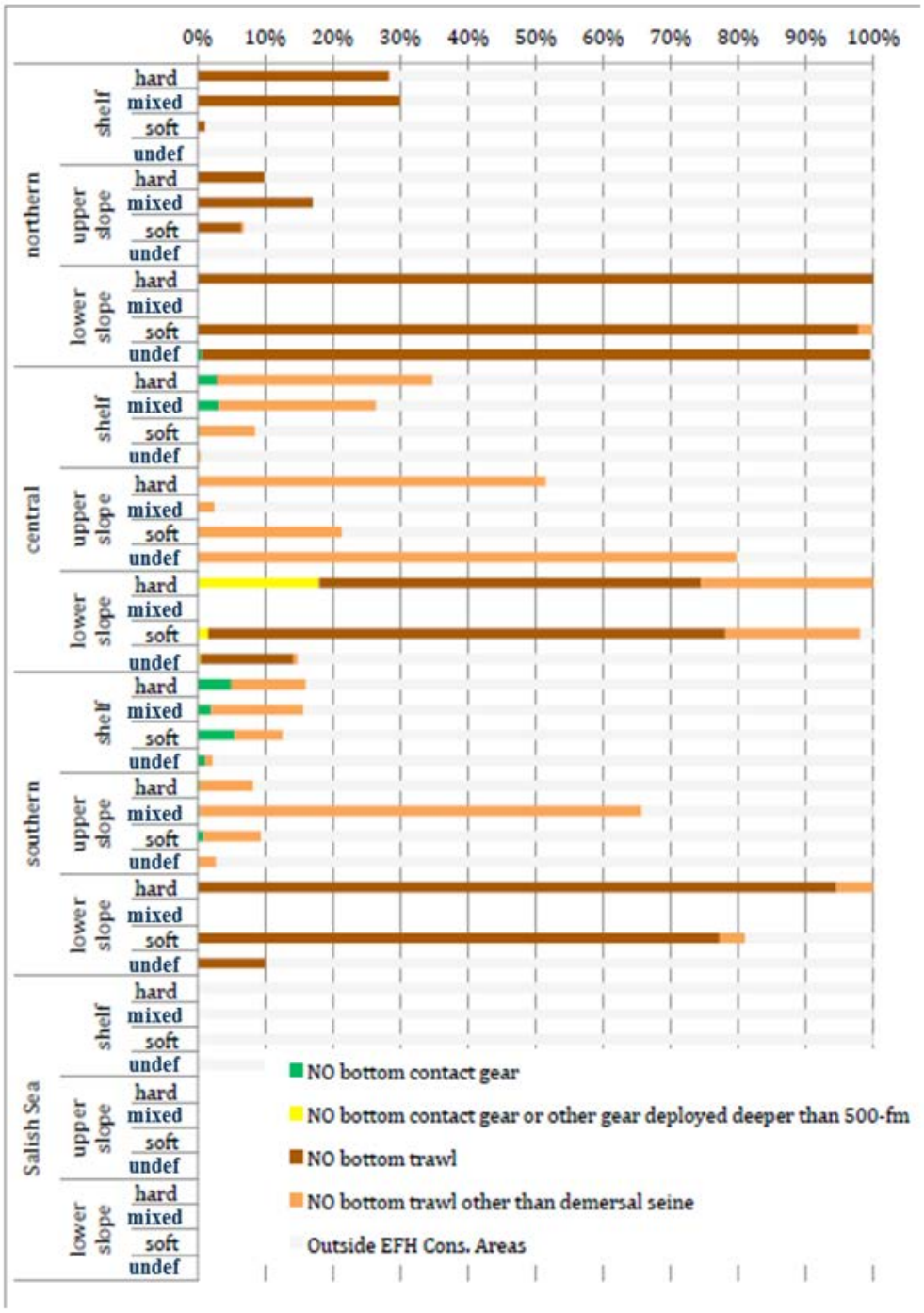

Figure 3. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where EFH-specific gear prohibitions apply (from NMFS Groundfish EFH Synthesis Report [NMFS 2013a]). No EFH Conservation Areas are located in the "Salish Sea" and no "mixed" substrate types are known to occur with the lower slope of any biogeographic sub-region.

Additional information or analyses that are needed to improve our understanding of this objective include:

- Improve mapping and description of benthic habitats at spatial scales relevant to groundfish species on Continental Shelf and Slope of West Coast
- Evaluate protected vs. non-protected areas, for example:
    - Total area of habitat types protected (i.e. not just Amendment 19)
    - Species-specific protections

Metrics that could be developed into criteria to evaluate Amendment 19 relative to this goal, include but are not limited to:

Relative and absolute proportions or area of habitat types with and without protections

b) Protect the full range of benthic habitat to account for each managed species;

Along the U.S. West Coast, habitat types have received differential protection from fishing effort. The proportion of habitat with a high probability of occurrence of representative groundfish species and also included within an EFH conservation area varies widely among species. These conclusions were derived from the analysis in the Groundfish EFH Synthesis (see discussion in EFH-S [Section 2, pg. 22-38], EFH-P2 [Section 3, pg. 13-17]). Those species that occur in rocky or deeper areas (e.g., yelloweye rockfish, sablefish, and longspine thornyhead) have a relatively higher proportion of their habitat included within the EFH conservation areas than fish that are generally found in shallower or softer habitats (petrale sole, greenstriped rockfish, darkblotched rockfish). In addition, fishing pressure was high in high-probability habitat for adults of some groundfish species but not in other areas.

Species vary in the coincidence of habitat suitability and fishing pressure from the groundfish fishery. For example, sablefish has the highest proportion of areas that are heavily targeted by the fishery and also have a high probability of occurrence. Petrale sole has high probability of occurrence and high fishing pressure near the mouth of the Columbia River (Washington/Oregon border) and near San Francisco, California, but areas of lower fishery pressure (from federally observed fisheries) nearshore. The estimated threat to yelloweye rockfish is generally low since yelloweye have a high probability of occurrence only in areas with a low exposure to bottom trawl fishing.

Given the insufficient amount of information on survival, fecundity, growth, or other life history parameters across habitat types at each life stage, an approach that works to protect a variety of habitats (i.e., Objective a) is consistent with precautionary fisheries management.

Additional information and analyses that could improve our understanding of this objective include:

- Improve surveys in untrawlable habitats
- Improve our understanding of the use of biogenic habitats by groundfish species
- Describe the distribution and abundance of larval and juvenile groundfish species across habitat types; identify core spawning and nursery grounds
- Evaluate habitat-specific variation in life-history parameters for individual species
- Improve life-cycle models that include habitat or spatial components

- Re-run Habitat Suitability Probability models in association with EFH closures to evaluate effectiveness at a species/life history stage level
- Evaluate habitat affinity with species size
- Incorporate additional sources of information (e.g. NWFSC Hook and Line Survey) into species-habitat association analyses
- Evaluate the effects of climate change on groundfish habitat use

Metrics that could be developed into criteria to evaluate Amendment 19 relative to this goal, include but are not limited to:

- Relative and absolute proportions or area of habitat types with and without protections, coupled with species-specific habitat associations
- Population status metrics, including abundance, productivity, spatial structure and diversity

c) Prioritize pristine or sensitive habitats and the gear types most likely to have the highest impact;

Many fishes associate with various types of structure, such as rocks, depressions in soft sediment, kelp, thermal gradients, man-made debris, and structure forming invertebrates (biogenic invertebrates). Bottom tending fishing gears have the potential to reduce habitat complexity by smoothing of sedimentary bedforms and reduction of bottom roughness, and removal of taxa that produce structure. Certain types of biogentic habitats are known to be particularly sensitive to the disturbances inflicted by fishing gear (see discussion in EFH-P1 [Section 4, pg. 55]). Both EFH-S (Section 2.2, pg. 27) and EFH-P2 (Section 3) discuss the potential importance of invertebrates such as corals and sponges in enhancing complexity of seafloor habitats and the sensitivity of these organisms to impacts from fishing gear. Our understanding of the location of these biogenic habitats has improved over the past decade, but remains far from perfect.

Deep sea corals and sponges (DSC) along with other structure forming invertebrates mostly occur on rocky substrata (e.g., boulders, pinnacles, rock outcrops), although sea pens in particular are found in mud and sand sediments. Many FMP groundfish species, especially the rockfishes, co-occur with DSC in the same rocky areas. DSC taxa are slow growing and vulnerable to disturbance by bottom-tending fishing gears that target North Pacific groundfish species. As a result of added protections from Amendment 19 (as described in a), such habitat is being protected via the exclusion of fisheries from hard substrate locations.

Additional information and analyses that could improve our ability to address this objective include:

- Improved habitat mapping (see Objective a)
- Greater understanding of the distribution and abundance of biogenic habitats on a lower taxonomic level than presently available
- Observational and experimental studies to evaluate the impact and recovery from different gear types on all habitat types

Metrics that could be developed into criteria to evaluate Amendment 19 relative to this goal, include but are not limited to:

- Relative and absolute proportions or area of habitat types with and without from different gear types
- Distribution of fishing and non-fishing impacts across habitat types (e.g. intensity or number)

d) Distribute socioeconomic costs that would result from implementation of the alternative;

To date, no work has been done that evaluates the Amendment 19 socio-economic costs and benefits, or their distribution across regions or participants. Previous analysis has noted that the distribution of fishing effort has changed since the establishment of the RCA to areas that are deeper and somewhat more offshore. No similar shift in fishing effort was observed with respect to the closures established by Amendment 19 (see EFH-S [Section 5.2, pg. 91-92).

Additional information and analyses that could improve our ability to address this objective include:

- Evaluation of changes in landings and ex-vessel revenue across communities or port groups of interest. The analysis could look at the effect by:
    - Species of interest
    - Fishing gear
    - Vessel classifications or characteristics
    - Other factors of interest
- Evaluation of regional economic impacts resulting from changes in landings by port group:
    - Economic output
    - Employment
- Evaluation of potential changing in the net returns to fishing and processing due to:
    - Changing is areas fished
    - Changes in catch rates
    - Changes is landed species mix
- Evaluation of the economic effects of other spatial management efforts.

These evaluations could be developed into criteria.

e) Implement area closures for different gear types within different habitat types to foster comparative scientific research

EFH closures were not explicitly designed as a comparative experiment to measure effectiveness of the closures. However, a recent study by Keller et al. (in press) examined the distribution of demersal fishes along the U.S. West Coast in relation to the Rockfish Conservation Area (RCA), and suggested that such area closures can be an effective management tool for conserving many of the groundfish species. Keller et al. used trawl survey data from 2003 to 2011 to evaluate the influence of RCAs on catch per unit effort (CPUE), species richness, and size distribution of demersal fishes. During the study period, both catch and species richness were greater in the closed portion of the RCA and a higher proportion of larger fish occurred within the RCA boundaries. Despite a declining trend in demersal fish biomass in general along the West Coast (Keller et al.2012), CPUE within the closed region of the trawl RCA also decreased but remained high relative to other areas for multiple species. Although the RCA closure is not part of the network of EFH conservation areas, these results from Keller et al. (in press) can inform

our understanding of the effects of spatial closures on demersal fishes. In particular, comparative analyses of catch and diversity of groundfish species could be conducted between EFH Conservation Areas and areas with no prohibitions in order to evaluate performance of Amendment 19 closures.

Additional information and analyses that could improve our ability to address this objective include:

- Compare catch, species richness, and size distribution for demersal fishes inside and outside of the boundaries of the EFH Conservation Areas and other protected areas
- Maintain closures for periods of time long enough to support research on the impacts of the closure on both the habitat and on species' distribution, abundance, and growth
- Establish closures in a full range of habitats and across relevant gear types in the context of a planned experiment

3 Evaluating the Effectiveness of EFH Conservation Areas

A habitat assessment is a fundamental and key element in evaluating the effectiveness of spatial management measures, such as the implementation of the Amendment 19 EFH Conservation Areas. Habitat assessments are designed to address the PFMC's request to provide a potential approach to evaluating the question of whether current EFH designations are working as expected. In developing both the 2005/06 and current 5-year reviews of groundfish EFH, NMFS mirrored the science guidance and pathways outlined in the NMFS HAIP Plan, emphasizing data consolidation and synthesis to inform a habitat assessment and policy development. This framework is highlighted in Figure 4, taken from the NMFS HAIP.

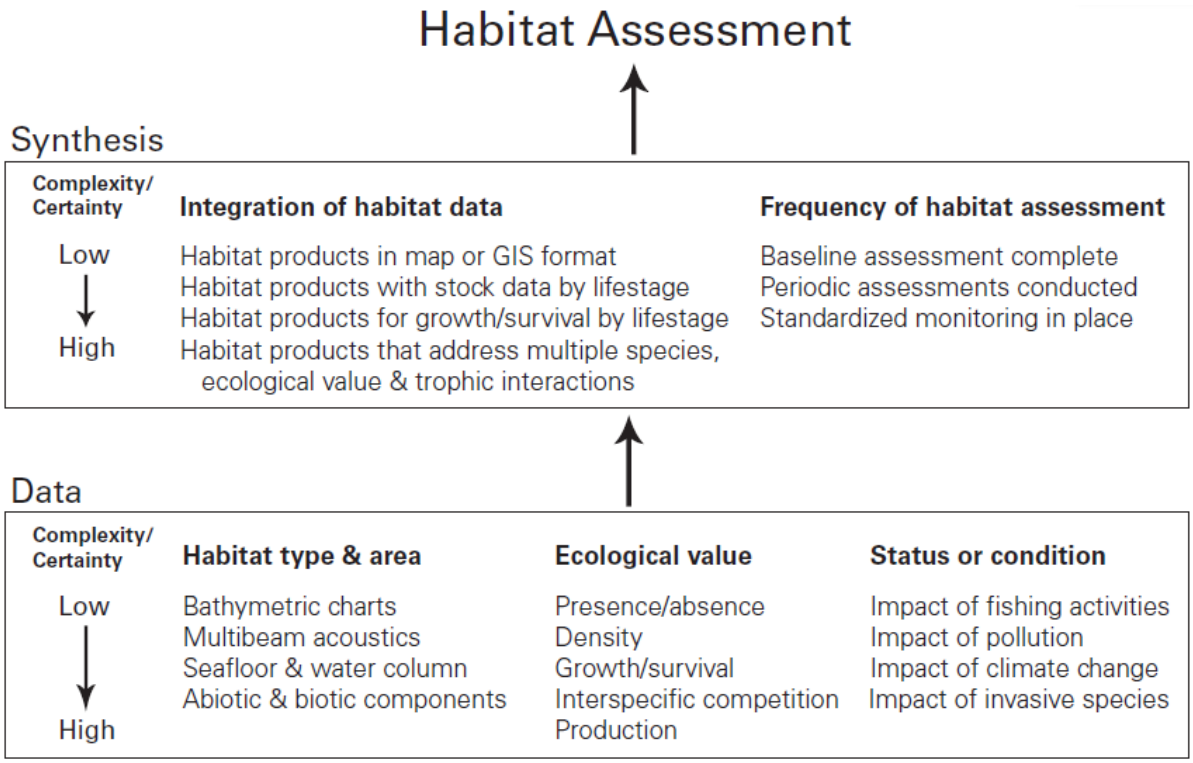

Figure 4. Flow of information in the development of a habitat assessment from the data gathering phase through the synthesis phase leading to policy development (from NMFS Habitat Assessment Improvement Plan [NMFS 2010]).

We can approach the problem of evaluating the effectiveness of spatial management measures as a series of four steps:

1. Collate knowledge of the state of each of the biological and physical habitat attributes across the entire coast.
    a. Occurrence and/or abundance of each habitat attribute
        i. These will typically take on the form of a chart or table, or, in the case of more dynamic attributes, a series of charts or tables.

2. Connect the measured state of each attribute to its effect on each species and life-history stage. The effect of physical and biological habitat could be identified in a range of species life history parameters including:
    a. Growth
    b. Mortality
    c. Recruitment
    d. Species Interactions

    Individually, these effects of habitat provide "level 3" information and in combination they are a measure of the productivity of the species or "level 4" information. Because Step 2 can be difficult in any environment, NOAA and other researchers have developed associations between the distribution of a species and the habitats in which it is most commonly found.

3. Combine the effects of each habitat attribute to arrive at a cumulative measure of the quality of each potential location for the entire coast (again for each species and life-history stage). Importantly, given the information gaps presented in the previous section, this has to be done in the presence of uncertainty about the actual habitat along the coast.

4. Combine information across all species and life-history stage metrics to determine which areas should be protected to maximize the quality of habitat for all species and life-stages simultaneously for given a set of biological and socio-economic constraints

Estimated Resources Needed by both NW and SW Fisheries Science Centers to Advance Groundfish Habitat Assessments for the US West Coast – Turning to the NMFS Habitat Assessment Improvement Plan

In 2009, the NMFS HAIP team asked NMFS habitat and ecosystem scientists, population/stock assessment scientists, and resource managers to identify the most important factors hampering their ability to provide accurate, precise, valid, and defensible habitat assessments (including data collection, analyses, and reporting) that would assist in improving accuracy and precision of stock assessments and EFH/HAPC designations (NMFS 2010). The quality of habitat assessments was considered using a series of tiers in a manner similar to the NMFS Stock Assessment Improvement Plan (SAIP) (NMFS, 2001). The three tiers of the HAIP included the essential elements of a comprehensive habitat assessment and monitoring program: habitat-specific biological information, geospatial information on habitat characteristics, and development and application of indices to monitor habitat condition related to fish production. The tiers indicate increasing levels of resolution in assessment data and an increased understanding of the functioning of fish habitats.

Across NMFS, the major obstacles to producing and using credible habitat assessments were:

- Lack of fishery-independent, habitat-specific abundances and biological parameters;
- Insufficient staff to collect, process, analyze, and model habitat data; and
- Insufficient research on environmental and multispecies effects.

Program managers at the NW and SW Science Centers estimated that the equivalent of 96 additional full-time staff devoted to habitat research and assessments are required to achieve tier 2 assessments (that is, to produce habitat maps over the geographic range of all stocks and life stages and to determine their habitat-specific abundances) for all species under PFMC jurisdiction (see Appendix 7 of NMFS HAIP); groundfish account for about 75% of the total number species. Meeting the objectives of Tier 3 assessments would require 78 additional staff.

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