Exhibit C.6.c
Attachment 1
April 2004

A Review of Analytical Portions of the Environmental Impact Statement for Designating Groundfish Essential Fish Habitat

– A Report of the SSC Groundfish Subcommittee –
Based on a Meeting Held at the Alaska Fisheries Science Center, February 23-24, 2004

SSC Members Present:

Steve Ralston (chairman)
Martin Dorn (rapporteur #1)
Mike Dalton (rapporteur #2)
Steve Berkeley
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Introduction

NOAA Fisheries is developing an Environmental Impact Statement (EIS) in response to a court order and settlement agreement to conduct a new NEPA analysis for Amendment 11 to the Pacific Fishery Management Council's (PFMC) groundfish Fishery Management Plan (FMP). Work on the EIS officially started in March 2002, when a team of NMFS and NOS scientists convened to devise a strategy and to identify data sources and responsible parties. The team identified the comparative risk assessment model described by the NRC[1] as the conceptual starting point for the Pacific coast groundfish Essential Fish Habitat (EFH) EIS. The PFMC reviewed the decision-making framework in April 2002 and subsequently formed the PFMC's Groundfish Habitat Technical Review Committee (TRC) to guide the assessment process.

The full Scientific and Statistical Committee (SSC) received an initial briefing by the EFH analytical team in June 2003. The schedule for designation of EFH by the PFMC is mandated by court order and requires that a range of alternatives be available for consideration at the June 2004 Council meeting. Scientific input has largely been provided to the analytical team by the Technical Review Committee (TRC) convened by the council. However, given the rigid schedule that is required for adoption of EFH alternatives by the PFMC and the role of the SSC in advising the Council about scientific and technical issues, a review of analytical tool that has be developed to evaluate EFH options was requested of the groundfish subcommittee of the SSC. That review was conducted February 23-24, 2004 at the Alaska Fisheries Science Center in Seattle, Washington. A substantial set of briefing materials were provided (Appendix 1) to the six members of the SSC that were present for the review (Ralston, Berkeley, Dalton, Dorn, Jagielo, and Lai).

It is clear that considerable advancement has occurred since the SSC was initially briefed by the EIS analytical team. The most substantial progress has been made on developing methods for characterizing and designating EFH. However, at the time of the review the fishing impacts model was not yet complete (see below).

The goal of the analytical team has been to bring a completed EFH assessment to the council at the April meeting, where preliminary alternatives for designating EFH will be presented. Council staff anticipated that the review by the groundfish subcommittee would constitute a "final check" before the completed assessment is brought before the Council. Although significant progress has been made, aspects of the analysis are incomplete (i.e., the fishing impacts model), precluding SSC endorsement of the full EIS assessment. Nonetheless, the subcommittee was able to fully review the analytical tool for designating EFH, for which methods have been most fully developed.

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[1] NRC (2002). Effects of Trawling and Dredging on Seafloor Habitat. National Research Council, Ocean Studies Board, National Academy Press, Washington, D. C., 136 p.

Review of Model for EFH designation

GIS layers for bathymetry and substrate

Geographic Information System (GIS) techniques are used extensively in the EFH analysis. Information in GIS is stored as "layers" that can be linked together by their geographic coordinates. Two basic layers are used to characterize benthic marine habitats: a bathymetric layer (latitude-depth) and a substrate layer (geology of the sea floor). These layers have been assembled from many sources by the EFH analytical team and are the most comprehensive datasets of bathymetry and substrate ever compiled for the West Coast. The area covered extends from the shoreline (including estuaries) to 3000 m. This area does not comprise the entire West Coast EEZ, but does encompass the nearly all of the known habitat for groundfish FMP species. Areas of potential interest further offshore include several seamounts that rise above 3000 m depth that may provide habitat for minor groundfish species such as Pacific rattail and finescale codling. Omission of seamounts is unlikely to be of consequence for the EFH analysis, although they may good candidates for HAPC designation. The technical team indicated they will close this information gap in time for the seamount data to be useful in the EIS process.

Ideally, the quality of the data in a GIS layer should be assessed when the layer is created. A data quality layer is potentially useful in subsequent analysis to incorporate uncertainty, particularly when using Bayesian Belief Networks (BBN). For Oregon and Washington, a data quality layer on a scale of 1-40 was produced for each data source, i.e., bottom grabs, side scan sonar, seismic, etc. Unfortunately, a similar layer has not been generated for California. For the bathymetry layer, a qualitative scale was proposed, whereby a single value would be assigned to the waters off each state. Uneven treatment of uncertainty by layer and by region makes it difficult to carry forward uncertainty in the analysis.

In BBN models, uncertainty is modeled with discrete misclassification matrix, which could be obtained by evaluating an imprecise data set using a more precise data set, or from expert opinion. Unless uncertainty has been evaluated when the original layers were prepared, it is difficult to treat uncertainty appropriately. One option is to simply omit the misclassification matrix to acknowledge the difficulty of treating uncertainty appropriately. Another alternative would be perform a sensitivity analysis with different levels of classification error. Parcels identified for EFH analysis are irregular in shape, and defined according to depth intervals. While the range of depths within a parcel is likely to differ somewhat from the depth intervals used to define the parcel, the entire parcel is unlikely to be belong to a deeper or shallower depth interval. Therefore, we recommend that depth uncertainty not be included in the EFH designation model.

Biogenic habitat

Biogenic habitat (e.g., kelp, sea grass, and structure-forming invertebrates) is both of potential importance to fish populations and potentially sensitive to fishing impacts. With respect to structure-forming invertebrates, however, the draft analysis only provides a map showing the locations of survey stations were these species have previously occurred. Because of the potential importance of these biogenic habitats, the subcommittee recommends additional effort to identify areas with biogenic structure, including especially the structure-forming invertebrates. The review panel is cognizant of the limitations of the NMFS surveys for this purpose, and does not intend to be prescriptive in recommending what additional analyses could be done. Several suggestions are:

1. There currently exists a GIS layer with distribution polygons that characterizes kelp cover. This layer is needed to identify essential habitat for species with specific affinity for kelp habitat. However, the spatial extent of kelp cover expands and contracts in response to environmental variability (e.g., El Niño). When habitat is dynamic in nature, defining EFH by fixed geographic coordinates is problematic. Since the compiled information on kelp cover is the maximum extent of kelp cover, the kelp GIS layer should be understood as an inclusive definition of this habitat. Sea grass habitat presents similar difficulties.

2. Some structure-forming invertebrates are found primarily on soft bottom, and would be sampled effectively in the NMFS trawl surveys. Example include sea whips and perhaps sponges. For these soft bottom invertebrates, maps of relative CPUE by station should be produced.

3. The draft analysis argues that NMFS survey data are not adequate to produce a comprehensive map of hard-bottom coral off the West Coast. It is impossible to assess the adequacy of the survey data without first taking steps to map relative abundance. This exercise could also help to emphasize the need for further research into coral distribution, and ought to be included in the final analysis. Some areas of the West Coast EEZ have been surveyed using ROVs (i.e., Hecata Bank, parts of southern California). Assessing the distribution of coral in these areas is feasible. If at all possible, information on coral distribution in these areas should be included in the EFH analysis.

Modeling fish distribution

The NMFS guidelines for EFH describe a hierarchy of information that can be used to designate EFH. At level 4 (the highest) information is available on production rates by habitat. For the West Coast (as elsewhere), the information available for EFH designation is at level 2 (habitat-related density) and at level 1 (distribution data). Trawl CPUE is not explicitly habitat-related because substrate is not determined at sampling stations. Interpretation is also problematic because not all substrates are sampled equally well using trawls. The analytical team has devised an approach based on fitting generalized additive models (GAM) to presence/absence information (level 1) from trawls by latitude and depth (i.e., level 1). This approach ignores information on relative density from trawl surveys. While there are good reasons for adopting this approach, the change from a level 2 to level 1 analysis needs to be more carefully justified in the EFH analysis.

The information from literature review entered into the Habitat Use Database (HUD) is used to establish the species-substrate association. Habitat maps produced by EFH analysts show the “habitat suitability probability,” which is calculated as the product of probability of occurrence by latitude and depth (from the GAM model) and strength of the species-substrate association. This quantity can be regarded as an estimate of how likely it is that the species will be encountered in a habitat, so perhaps the nomenclature should reflect this. Habitat suitability is a relatively vague concept that implies more about the importance of a particular habitat than is perhaps warranted.

The approach to modeling of EFH has evolved considerably from the initial NOS models used for assessment of central California marine sanctuaries. Rather than polynomial regression using the logarithm of mean survey CPUE, the EFH model is a GAM model for the probability of occurrence. The final modeling approach is based on appropriate error assumptions and careful attention to goodness of fit. Nevertheless, there is some concern that the modeling approach does not make fullest use of the survey information on relative densities. GAMs and GLMs that can accommodate zero catches have been commonly used to obtain indices of abundance using West Coast trawl survey data for stock assessment. Furthermore, the limitations of presence/absence information to infer essential habit should not be ignored. For example, a species may have a broad depth or geographic distribution, but may only reach high densities in a limited area. Surveys provide limited information concerning the function of the habitat for a species. For example, winter spawning grounds for lingcod would not be necessarily be identified as essential habitat using summer survey data.

Existing surveys also have a strong bias towards habitats that can be trawled, and are of limited utility for identifying essential habitat for juvenile stages. For example, biogenic habitat may provide refugia from predation for juvenile fish, yet these habitats could not be identified as essential if the sampling gear does not capture juveniles. Although direct visual surveys are perhaps the best method for identifying species-habitat associations, these surveys are currently limited in scope. Size composition data are available for many groundfish from the NMFS trawl surveys. In many cases, juveniles can be reliably distinguished from adults on the basis of size. Many species occupy different habitats at different life history stages. Information about these ontogenetic shifts present in the trawl data is not being utilized in the present analysis. Therefore, while presence-absence analyses should be relatively robust, EHF designations resulting from such analysis are initial approximations that will need to be refined as additional information becomes available.

Habitat profiles have been generated for adults using GAM models and NMFS survey data for a limited number of species. Habitat profiles have not yet been obtained for egg, larval, and juvenile stages. These profiles will be generated using the HUD database, which will also be used for the adult stages of species which are not well sampled during trawl surveys.

Although this work has not yet been completed, the subcommittee was able to review the proposed methods.

HUD database

The life history appendix to the previous EFH amendment to groundfish FMP has been made into relational database of habitat use (HUD). For each species, association with substrate type is characterized on a relative scale (unknown, weak, medium, strong). Depth preferences are characterized with four depths: minimum observed depth, minimum preferred depth, maximum preferred depth, and maximum observed depth. Geographic (latitude) preferences are recorded similarly. The preferred minimum and maximum depths (and latitudinal ranges) are roughly based on the 5^{th} and 95^{th} percentiles from surveys when these data are available.

The analytical team proposed an interpolation/smoothing procedure for inferring habitat suitability profiles using information on preferred depths and latitudes in the HUD. While trying to extract as much information as possible from limited data is laudable, there is some danger of over-interpreting data to obtain visually satisfying results. Linear interpolation is preferable to arbitrarily smoothed curves when obtained simply from preferred maximum and minimum preferred depths. Values used to control the shape of suitability profiles could be estimated objectively by comparison with survey-based profiles for species where both can be obtained.

Model for EFH designation

The Bayesian Belief Network model used for designating EFH appears to be a reasonable approach. The EFH model is a very straightforward application that does not depend heavily on BBN methodology (Fig. 1 shows the flow of information in the EFH habitat designation model.) The novelty of the approach should not be considered a significant issue.

The end result of the EFH analysis are maps by life history stage for each groundfish species that show on a qualitative scale the importance of different habitats to that species. EFH is determined by selecting habitats with scores higher than some predetermined value. A low value would produce a broad or inclusive definition of EFH, while a high value would reduce the area defined as EFH. The decision whether to adopt an inclusive or narrow definition of EFH should be considered from a policy standpoint. Adopting an inclusive definition may be appropriate given the incomplete and indirect nature of the information used to identify EFH. However, developing workable alternatives to reduce fishing impacts may be difficult if EFH is defined broadly. Adopting a relatively narrow EHF definition may make it easier to develop effective precautionary alternatives.

The GAM models estimate the probability of occurrence, while suitability profiles based on HUD database are scaled to have a maximum value of one. The probability of occurrence can have a maximum value considerably less than one, particularly for rare species where the probability of occurrence is low everywhere. EHF for individual species should be placed on common scale before they are combined in an EFH definition for all groundfish species. It may also helpful to produce intermediary maps showing EFH maps for various subsets of groundfish, i.e., overfished species, species guilds, or species complexes used for management. One promising alternative for EFH designation would identify the best 10% (or 20%, etc) of habitat over entire assessed region for each groundfish species, and then combine these areas for an overall definition of EFH.

Public comment concerning EFH

1. The final rule for NMFS guidelines discusses the need for different EFH definitions for overfished species.

2. There is concern about using a level 1 analysis (presence/absence) rather than a level 2 analysis (relative density).

3. Is HAPC contained within EFH? Answer: Criteria for defining HAPC are different than EFH. HAPC is not necessarily included in EFH.

4. There was public testimony concerning the importance of identifying areas with living structure (specifically, corals and sponges).

SSC Review of the Impacts Model for the EFH EIS Process

Fishing Effort

Spatial data requirements of the EFH project stretch, and in many cases exceed, what are available for most West Coast fisheries. The most comprehensive spatial data for fishing effort on the West Coast are available from trawl logbooks, and work on the EFH project so far has relied exclusively on these data to measure the spatial distribution and intensity of impacts from fishing. The development of spatial data for fixed-gear sectors is an important objective for the EFH project's fisheries impacts model.

For the trawl fisheries, impacts are measured in the EFH project by total tow hours in a year at each location, or fishing block, where trawling occurred. This definition of fishing effort is appropriate for the EFH project.

No coast-wide source of spatial data for fixed-gear fisheries exists. Recently, the Ecotrust organization developed a model to estimate the coast-wide spatial distribution of fishing effort for fixed-gear and other groundfish fisheries using information from fish tickets, but the accuracy of these distributions was not tested. Wisely, the EFH project team investigated the potential reliability of using Ecotrust's effort distributions to represent spatial distributions of fishing effort in trawl, long-line, and groundfish pot fisheries. To check Ecotrust's effort distribution for one area, focus group meetings with knowledgeable fishermen were conducted to develop baseline effort maps for an area off the Oregon coast.

The focus group meetings for the EFH project were conducted under sound socioeconomic research protocols (Final Report, Pilot Project to Profile West Coast Fishing Effort). The SSC endorses the use of social science research methods to collect primary data based on fishermen's knowledge and expertise. The SSC encourages further use of these methods to continue collecting primary data on baseline fishing effort off the West Coast. These data would be used to develop baseline effort maps for other areas, and provide the best available science to the EFH-EIS process.

The focus groups produced a set of maps showing the spatial extent and intensity of fishing effort for trawl, long-line, and groundfish pot fisheries in an area between the ports of Newport and Astoria. Based on survey responses, fishermen in the focus groups were confident in the spatial extent of fishing effort depicted on the maps, but uncertain about the groups' estimates of the spatial intensity of fishing effort.

Maps from the EFH project's focus group were compared to Ecotrust's distributions of fishing effort for fixed-gear fisheries between Newport and Astoria over two recent time periods, 1997 and 2000. To show results, the EFH project team provided several maps that compare the baseline effort maps from the focus groups with Ecotrust's effort distributions. Results of the comparison are discouraging. For example, the areas reported by the focus groups for the fixed-gear fisheries were generally much larger and further from port than Ecotrust's distributions.

For the long-line fishery, Ecotrust's distributions cover 8-12% of the area reported by the focus groups. On the other hand, around 50% of each Ecotrust's distribution is outside that area. Results of the comparison for the groundfish pot fishery are worse. In this case, Ecotrust's distributions cover only 0-3% of the area reported by the focus groups, and 80-100% of each Ecotrust distribution is outside that area. In one case, the center of Ecotrust's distribution is more than 100 km from the area identified by the focus groups.

These comparisons reinforce the SSC's concerns, which have been described previously, regarding the spatial algorithm used by Ecotrust. Based on the above comparisons, the SSC is doubtful that the effort distributions derived from the Ecotrust methodology broadly represent baseline patterns of fishing effort in non-trawl fisheries. Consequently, the SSC cautions against relying on those effort distributions, to avoid biasing the estimated spatial distribution of impacts from non-trawl fisheries.

Effects of Fishing Gear on Habitat: Sensitivity and Recovery Rates

The EFH project team conducted an extensive literature review, and developed a database of gear effects for different habitat types. As with any multi-dimensional classification system, the number of cells requiring data grows quickly as more gear or habitat types are added to the database. Information to fill these cells is constrained by the literature review. To allow a reasonable number of cells, a scoring system was developed to rank gear effects with three levels each for sensitivity and recovery times (Tab. 2, p. 12, Appendix 10).

Data from the literature were standardized and a given a score in the range 0-3. For habitat sensitivity, zero represents minimal effects or no impact, and a score of three represents a major or catastrophic effects. Recovery times range from zero to periods lasting from three to seventeen or more years. For this reason, interpretation of the scores as real numbers is problematic. Nonetheless, scores are added together to calculate average scores for sensitivity and recovery rates.

The literature review provided a robust ranking of gear types by damage per unit effort, in increasing order: hook and line, pots and traps, nets, trawl, and dredges. The literature review also provided a robust ranking of habitat sensitivities to gear effects, in increasing order: soft bottom, hard bottom, and biogenic (broadly defined as having vertical biological structure).

The SSC notes the biogenic habitat category needs attention. Ideally, a refinement of this category could include corals, sea pens, or other invertebrates, but spatial data exist only to partly support this formulation. While the incomplete distributions may not be appropriate for use in the Bayesian network model, maps showing the spatial distribution of known biogenic features (e.g. corals in trawl surveys), and the distribution of fishing effort, would be useful for reference in future documents. In addition, the SSC notes that refinement of other categories, such as soft sediments, may also be advised.

Scores assigned to different gear and habitat types from the literature review involved subjective judgment. To address this issue, scores were assigned independently by a group of researchers that rated studies in the literature review. The mean of the individual scores, plus or minus a standard deviation, is used to represent low, medium, and high values for each gear and habitat type.

Overall, the SSC finds this method of constructing habitat sensitivity and recovery indices to be acceptable, but is concerned about whether data from the literature review are sufficiently representative of West Coast fisheries. Only 2 of the 89 studies included in the literature review took place in West Coast fisheries. Another potential source of bias is that 90% of the studies are about trawl or dredge gear.

Of particular concern to the SSC is the use of gear effect estimates from studies on New England trawlers to infer habitat effects from West Coast trawl vessels, which are usually smaller with different gear characteristics. Effects of trawling on hard-bottom shelf habitats are likely to be important in West Coast fisheries, and estimates of sensitivity and recovery for the hard bottom-shelf-trawl category in the EFH database are from only two studies (Tab. A10.2, Appendix 10 attachment). One study is about beam trawls, and the other was done in New England (Auster et al., 1996).

The SSC recommends investigating the relationship between gear effects and vessel size or fishing power, and if necessary controlling for this factor in the gear effects tables. A related issue that deserves further investigation is an assessment of each gear type's ability to access different habitat types.

Clarification is needed about relationships between the overall level of fishing effort and gear effects. For example in most cases, gear effects are measured for a single trawl, but replicates are sometimes used. Questions were also raised about whether replicate trawls occurred at exactly the same location. An important uncertainty in the data is that overall effort is controlled in the studies, and results may not apply, or may apply only in a limited way, to situations where effort is not controlled.

Fishing Impacts Model

The fishing impacts model for the EFH-EIS analysis is work in progress, and the SSC was unable to conduct a full review of the model at this time. The fishing impacts modeling team has a complex, and impressive, set of tasks to complete in order to accomplish its stated objectives. Fortunately, major computational challenges related to model development, and execution, have been solved, and a working version of the model and data were used to produce quantitative results for the effects of gear on fish habitat. The SSC appreciates the EFH project team's openness, particularly regarding suggestions about future model development.

Currently, the fishing impacts model is reduced to a single index value that is intended to represent a broad measure of status for fish habitat based on cumulative impacts. Fishing effort and sensitivity of habitat to gear type determine gross impacts. The fishing impacts model is dynamic, and effects of recovery and previous impacts determine net impacts. A simplifying assumption is that fishing effort is uniformly distributed over the year, which might ignore important seasonal effects. Dynamics of the habitat index value are based on a logistic difference equation, similar to population models. Parameters in the logistic equation are linked to habitat sensitivity and recovery rates from the gear effects tables described above.

The single index variable can be used with different model formulations. In one formulation, the index value represents a mean or average status for fish habitat over an entire area. An alternative formulation is to assume that fish habitat consists of many individual patches that follow a discrete two-state process between healthy and damaged conditions. Under this interpretation, the index value represents the fraction of patches in, for example, the damaged state. Either formulation has problems, and the SSC recommends developing a multivariate description of impacts, based on explicit and measurable physical effects of gear on habitat, in terms of individual species, or types of organisms.

Saturating functions for gross impacts, and logistic (S-shaped) recovery profiles are important features to be added to the fishing impacts model. The SSC notes that a stochastic or probabilistic model of fishing impacts may be appropriate. Another alternative worth considering is the development of a spatially explicit model of gear effects that incorporates the notion of a gear footprint, such as the area swept by trawls, and whether a focus group approach similar to that for fishing effort could be pursued to estimate footprints for different gear types.

Impacts from Non-fishing Activities

The EFH team's work on impacts from non-fishing activities is just starting, with some data but no model to review. Modeling the impacts of non-fishing activities is important, but the SSC recognizes these activities are outside the control of fisheries management.

Appendix 1. Briefing materials presented to members of the SSC Groundfish Subcommittee for their review of the EFH EIS analytical tool.

1. Pacific Coast Groundfish EFH – **Analytical Framework** (Version 4, February 10, 2004). Prepared for Pacific States Marine Fisheries Commission by (a) MRAG Americas, Inc., 110 South Hoover Blvd., Suite 212, Tampa, FL 33609, (b) Terralogic GIS, Inc., P.O. Box 264, Stanwood, WA 98292, (c) NMFS Northwest Fisheries Science Center, FRAM Division, and (d) NMFS Northwest Regional Office, 89 p.

2. Appendix 1: Active Tectonics and Seafloor Mapping Laboratory Publication 02-01 – Interim Seafloor Lithology Maps for Oregon and Washington (Version 1.0), by C. Goldfinger, C. Romsos, R. Robison, R. Milstein, and B. Myers, Active Tectonics and Seafloor Mapping Laboratory, College of Oceanography and Atmospheric Sciences, Oregon State Unversity, Burt 206, Corvallis, OR 97331, 11 p.

3. Appendix 2: Final Report – Essential Fish Habitat Characterization and Mapping of the California Continental Margin, by G. Greene and J. Bizzarro, Center for Habitat Studies, Moss Landing Marine Laboratories, Moss Landing, CA, 21 p.

4. Appendix 3: Organizations contacted for information on non-fishing impacts to EFH, 6 p.

5. Appendix 4: List of groundfish species in life histories appendix, 2 p.

6. Appendix 5: Gear types in the PACFIN data base, 2 p.

7. Appendix 6: Description of habitat suitability index (HSI) modeling conducted by NOS, 4 p.

8. Appendix 7: Development of profiles of habitat suitability probability based on latitude and depth for species and life stages in the Groundfish FMP, 34 p.

9. Appendix 8: Discrete time damage model for fishing impacts, 3 p.

10. Appendix 9: Useful websites on Bayesian Belief Networks, 1 p.

11. Appendix 10: Pacific Coast Groundfish EFH – The effects of fishing gears on habitat: west coast perspective (Draft 5), by MRAG Americas for the PSMFC, February 9, 2004, 32 p. + annex.

12. Appendix 11: Pacific Coast Groundfish FMP Habitat Use Database User Manual for Version 15B (Draft), 50 p.

13. Non-Fishing Impacts on Bottom Habitats – Draft 1 (February 19, 2004), 7 p.

14. Letter from Dr. M. Mangel to S. Copps (dated 17 October 2003) concerning the Ecotrust Methodology, 2 p.

15. Final Report – Pilot Project to Profile West Coast Fishing Effort Based on the Practical Experience of Fishermen, by T. Athens, A. Bailey, F. Conway, S. Copps, R. Fisher, M. Larkin, S. McMullen, and F. Recht, 31 p.

16. Fishing Effort GIS Data Exploration for West Coast Groundfish EFH EIS Project, Terralogic GIS, December 2003, 20 p. + appendices.

17. Excerpt from Northwest Power and Conservation Council's Independent Science Advisory Board Report on Salmonids Supplemental, Section 7. Benefit-Risk Assessment and Decision Making, 19 p.