North Pacific Fishery Management Council

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Research Priorities and Needs

The North Pacific Fishery Management Council has developed a list of research needs and priorities, in three parts. This document contains the following sections:

- Research Priorities for 2007–2008
- Research Priorities for 2007–2012
- Comprehensive Research Needs for North Pacific Fishery Management

Research Priorities for 2007–2008

I. Fisheries

A. Stock Assessments

1. Continuation of annual and biennial surveys in the GOA, AI and EBS are a critical aspect of fishery management in Alaska. It is important to prioritize these surveys in light of recent proposed federal budgets in which funding may not be sufficient to conduct these surveys. These surveys provide baseline distribution and abundance data that form the foundation for stock assessments and the development of ecosystem approaches to management. These surveys are considered the highest priority research activity contributing to assessment of Alaskan groundfish fisheries. Moreover, the expansion of routine surveys into the northern Bering Sea and baseline surveys of the Arctic Ocean will become increasingly important under ongoing warming ocean temperatures and range expansions of harvested fishery resources. In particular, increase the annual survey to include the North Bering Sea Research Area (NBSRA) "wedge"[1]. The Council recognizes that funding is tight for stock assessment and surveys. If additional funds are not available, NMFS should consider a scientific research plan that provides a baseline in this relatively untrawled NBSRA as well as "cost recovery" in the "wedge".

2. Continuation and expansion of cooperative research efforts to supplement existing surveys to provide seasonal or species specific information for use in improved assessment and management

3. Improved stock assessment of "other species," non-target crab and rockfish. Highest priority research tasks include: (1) alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate; and (2) life history information (specifically, natural mortality, size at maturity, and other basic indicators of stock production) for "other species" and non-target crab to allow application of Tier 5 or Tier 4 assessment criteria. Little information is available especially for sculpins, skates, octopuses, squids, grenadiers and some sharks. In particular for rockfish, conduct appropriate survey and analysis to aid the Council in developing mechanisms to assess species that are locally lumped in their distribution and are thus not adequately represented (either over or under estimated) in the annual or biannual groundfish surveys.

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[1] The "wedge" refers to the area between St Matthew and Nunivak Islands, north to 60˚ N. The longitudinal expanse between the two islands has been reported as the first area likely to be utilized by the flatfish trawl fleet, if the sea ice edge moves and fish stocks migrate northward.

B. Fishery Management

1. Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels using Tier 5 and 6 approaches for rockfishes and other poorly assessed species (e.g., squid, octopus, skates, non-target crab).

II. Fisheries Interactions

A. Bycatch and Observer Issues

1. Improved estimation of total bycatch including tier 2 marine mammals and seabirds. At present, it is clear that observer coverage in some fisheries is insufficient for estimation of total bycatch. Further, observer coverage must be analyzed to compare, to the extent possible, the total catch, bycatch, and fishing behavior between observed and unobserved fishing vessels. Examples include the CV trawl fisheries, sablefish longline fishery, skate fishery, Pacific cod pot and longline fishery, halibut longline fishery, and sport fisheries. Improved accuracy of identifications and enumerations of bycatch species is necessary. The current program results in imprecise bycatch estimates for species, such as skates, sharks, yelloweye rockfish, and sablefish in halibut longline fisheries and discards in sport fisheries. Improved methods may include direct and alternative monitoring options (e.g., electronic logbooks, video monitoring) on smaller groundfish and halibut vessels.

2. Gear technology. Further research is needed on gear modifications and fishing practices for reducing bycatch, particularly for PSC species (e.g., salmon).

B. Expanded Ecosystem Studies

1. Climate change and fish communities. Changes in ocean temperature and acidity may affect managed species and lower trophic levels. For instance, if recent changes in ice cover and temperatures in the Bering Sea persist, they may have profound effects on marine communities. Apparent declines in zooplankton wet weight over the shelf measured by the Oshoro Maru could imply the loss of critical copepod and euphausiid prey of important species, such as pollock. Existing data sets (bottom trawl surveys, BASIS surveys) can be used to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands and other areas of the Gulf of Alaska.

2. Ecosystem structure studies. Studies are needed on the implications of food web interactions and global warming, ocean acidification, and selective fishing. For instance, studies are needed to fully evaluate selective removal of some components of the ecosystem (e.g., Pacific cod, pollock)

C. Protected Species Interactions

1. Population dynamics, life history and assessment of protected species including Steller sea lions, northern fur seals, spectacled eider, short-tailed albatross

2. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators such as Steller sea lions and northern fur seals, spectacled eider, short-tailed albatross. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals, seabirds, and the impact on benthic habitat by bottom contact gear).

III. Habitat

A. <u>Habitat Mapping</u>

1. Improved habitat maps are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming living substrates.

2. Evaluate Bering Sea canyons and skate nursery areas. In particular, an assessment of the extent, distribution, and abundance of important skate nursery areas in support of future HAPC.

IV. Other Areas of Research Necessary for Management Purposes

A. <u>Social and Economic Research</u>

Kodiak is at the center of controversy associated with the recently adopted crab rationalization program. What were the direct and indirect impacts and how were the impacts distributed throughout the community? How do these costs and benefits compare to other affected communities? As Kodiak is also likely to be at the center of controversy over the likely consequences of Gulf rationalization, it would be particularly advantageous if research could be designed to use Kodiak or other Gulf communities as case studies in analyses of the potential effects of Gulf rationalization options.

Research Priorities for 2007-2012

I. Fisheries

A. <u>Stock Assessments</u>

1. Continuation of annual and biennial surveys in the GOA, AI and EBS are a critical aspect of fishery management in Alaska. It is important to prioritize these surveys in light of recent proposed federal budgets in which funding may not be sufficient to conduct these surveys. These surveys provide baseline distribution and abundance data that form the foundation for stock assessments and the development of ecosystem approaches to management. These surveys are considered the highest priority research activity contributing to assessment of Alaskan groundfish fisheries. Moreover, the expansion of routine surveys into the northern Bering Sea and baseline surveys of the Arctic Ocean will become increasingly important under ongoing warming ocean temperatures and range expansions of harvested fishery resources.

2. Continuation and expansion of cooperative research efforts to supplement existing surveys to provide seasonal or species specific information for use in improved assessment and management.

3. Improved stock assessment of "other species" and non-target crab. Highest priority research tasks include: (1) alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate; and (2) life history information (specifically, natural mortality, size at maturity, and other basic indicators of stock production) for "other species" and non-target crab to allow application of Tier 5 or Tier 4 assessment criteria. Little information is available especially for sculpins, skates, octopuses, squids, grenadiers and some sharks.

B. <u>Fishery Performance and Monitoring</u>

1. Improvements in at-sea observations are needed in several areas: (1) species-specific identification of priority species on scientific surveys; (2) review and revision of observer deployment and coverage to adequately characterize total catch, as well as a review of sampling procedures (e.g., basket versus whole haul) employed by observers that form the basis for total catch estimation; (3) improved means of data collection especially on small vessels; and (4) improved biological data collection of bycatch species (e.g., octopus, squid, skates, sharks, and non-target crab).

2. Improved estimation methods for total catch and fishing mortality of all target and non-target species at the stock and fishery level as well as at the level needed for various management programs. This may include revised observer deployment, use of flow scales, etc.

C. <u>Fishery Management</u>

1. Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels using Tier 5 and 6 approaches for rockfishes and other poorly assessed species (e.g., squid, octopus, skates, non-target crab).

2. Advancing ecosystem approach to fisheries management. This includes development of suitable indicators and indicator species (including novel approaches such as using corticosterone levels in predators as an indicator of prey availability, developing ecosystem reference points, including OY cap considerations, and improvements of current ecosystem models.

3. Development of forecasting tools that incorporate ecosystem indicators into single or multi-species stock assessments to conduct management strategy evaluations under differing assumptions regarding climate and market demands. Standardization of "future scenarios" will help to promote comparability of model outputs. Process-oriented research focused on local impacts of fishing on prey availability for top trophic level consumers will also be informative.

4. Development of spatially explicit stock assessments that allow for management to be linked appropriately to stock boundaries and habitat use.

II. Fisheries Interactions

A. Bycatch

1. Improved estimation of total bycatch including tier 2 marine mammals and seabirds. At present, it is clear that observer coverage in some fisheries is insufficient for estimation of total bycatch. Examples include the sablefish longline fishery, skate fishery, Pacific cod pot and longline fishery, halibut longline fishery, and sport fisheries. Improved accuracy of identifications and enumerations of bycatch species is necessary. The current program results in imprecise bycatch estimates for species, such as skates, sharks, yelloweye rockfish, and sablefish in halibut longline fisheries and discards in sport fisheries. Improved methods may include direct and alternative monitoring options (e.g., electronic logbooks, video monitoring) on smaller groundfish and halibut vessels.

2. Research on discard and handling mortality rates. Better estimates of discard mortality rates by gear and fishery is needed to estimate more accurately total bycatch mortality for all discarded species, with an emphasis on such species as crabs, skates, sharks, rays, and octopus.

3. Gear technology. Further research is needed on gear modifications and fishing practices for reducing bycatch, particularly for PSC species.

B. Expanded Ecosystem Studies

1. Climate change and fish communities. Changes in ocean temperature and acidity may affect managed species and lower trophic levels. For instance, if recent changes in ice cover and temperatures in the Bering Sea persist, they may have profound effects on marine communities. Apparent declines in zooplankton wet weight over the shelf measured by the Oshoro Maru could imply the loss of critical copepod and euphausiid prey of important species, such as pollock. Existing data sets (bottom trawl surveys, BASIS surveys) can be used to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands and other areas of the Gulf of Alaska.

2. Ecosystem structure studies. Studies are needed on the implications of food web interactions and global warming, ocean acidification, and selective fishing. For instance, studies are needed to fully evaluate selective removal of some components of the ecosystem (e.g., Pacific cod, pollock) relative to others (e.g., arrowtooth flounder).

C. Protected Species Interactions

1. Population dynamics, life history and assessment of protected species including Steller sea lions, northern fur seals, spectacled eider, short-tailed albatross

2. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators such as Steller sea lions and northern fur seals, spectacled eider, short-tailed albatross. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals and seabirds).

3. Economic, social, and cultural valuation research (e.g., consumptive use, passive use, non-consumptive use).

III. Habitat

A. <u>Habitat Mapping</u>

Improved habitat maps are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming living substrates.

IV. Other Areas of Research Necessary for Management Purposes

A. <u>Social and Economic Rresearch</u>

1. Development of an ongoing database of product inventories (and trade volume and prices) for principal shellfish, groundfish, and salmon harvested by US fisheries in the North Pacific and Eastern Bering Sea. This database needs to include information about product form (e.g., canned, frozen, whole fish, fillets, value-added product, etc.), but does not need to be firm specific.

2. Analyses of current determinants of exvessel, wholesale, international, and retail demands for principal seafood products from the GOA and BSAI;

3. Kodiak is at the center of controversy associated with the recently adopted crab rationalization program. What were the direct and indirect impacts and how were the impacts distributed throughout the community? As Kodiak is also likely to be at the center of controversy over the likely consequences of Gulf rationalization, it would be particularly advantageous if research could be designed to use Kodiak or other Gulf communities as case studies in analyses of the effects.

4. Develop a framework for collection of economic information on commercial, recreational, charter fishing, and fish processing to meet the requirements of this MSFCMA sections 303(a)(5, 9, 13), 303(b)(6), and 303A.

Comprehensive List of Research Needs

I. Fisheries

A. <u>Stock Assessment</u>

The SSC notes that continuation of annual or biennial surveys in the GOA, AI and EBS are a critical aspect of natural resource management. These surveys provide baseline distribution and abundance data that form the foundation for stock assessments and the development of ecosystem approaches to management. These surveys should be considered a high priority research activity. Also the SSC notes that continued research on the life history of groundfish, crab and scallop should be considered an essential activity to improve stock assessments and management of managed resources. Critical life history research topics include: estimates of natural mortality (including temporal shifts in predation for target species), size-at-maturity or age-at-maturity (including environmental factors influencing maturity schedules), maternal effects (especially for Pacific cod and long-lived species such as rockfish), environmental impacts on growth, and environmental factors influencing reproductive success.

The following lists identify high priority research for groundfish, crab and scallops.

Groundfish

1. Rockfish – a general need for improved fishery independent estimates of abundance, catch, stock structure, and biological variables.
   a. Direct observations (e.g., submersible and dive surveys) to compare fish densities, particularly for rockfish, between trawlable and nontrawlable habitats.
   b. Improved surveys for minor rockfish species to verify range relative to standard surveys.
   c. Supplemental trawl survey biomass estimates to address patchy distribution.
   d. Age samples from the fishery, esp. POP, northern rockfish, and dusky rockfish. There is a need to increase the number of age determinations annually conducted for rockfish and to train researchers to make age determinations on species that are difficult to age.
2. Improved stock assessment of "other species." The SSC ranks items a, e, and f very high because they form the basis for a tier 5 calculation.
   a. Improved identification of priority species within each group in the fisheries by both processors and observers to avoid misidentifications, as well as categories containing large numbers of unidentified species.
   b. Species-specific identification of priority species on scientific surveys, including NMFS trawl and longline surveys, IPHC surveys, and ADF&G surveys.
   c. Increase knowledge of the acoustic sign types and target strength to length relationships to allow assessment of other targets during hydroacoustic surveys.
   d. Improved biological data collection via enhanced survey sampling, fishery port sampling and at-sea observations, including collection of lengths and age structures for priority species.
   e. Alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate. With an increase in the number needed stock assessments, it will be critical to develop alternative estimates of abundance and/or direct estimates of fishing mortality. Two possibilities that require dedicated research for development are: (1) directly estimate fishing mortalities through large-scale tagging programs; and (2) habitat-based estimates of abundance based on local density estimates in combination with large-scale habitat maps.

    f.   Life history information (specifically, natural mortality, size at maturity, and other basic indicators of stock production) must be improved for many members of the others species complex to allow application of Tier 5 or Tier 4 assessment criteria. Little information is available especially for sculpins, skates, octopuses, squids, grenadiers and some sharks.

    g.   Improved catch histories for groups in this complex for improved stock assessment and application of Tier 6 criteria. Greater use of historical foreign observer data is needed, as part of this activity.

3. Research is needed to incorporate seasonal movements, and stock boundaries of managed species into stock assessments. To identify stock boundaries, expanded studies are needed in the areas of genetics, reproductive biology, larval distribution and advection. Expanded tagging efforts are needed to support the development of spatially explicit assessments. High priority species for spatially explicit models include: walleye pollock, Pacific cod, sablefish, yellowfin sole, rock sole, Pacific Ocean perch, and Atka mackerel.

4. Incorporating uncertainty into the stock assessment advice. This requirement was proposed in the PSEIS, but progress towards amending the groundfish guidelines to address this issue has not been started. Management strategy evaluations are also encouraged because these evaluations serve as useful tools to assess the efficacy of harvest control measures under different assumptions regarding stock production.

5. Efforts to incorporate ecosystem considerations into stock assessments should be accelerated through research to improve knowledge of the functional relationship between environmental factors (e.g. physics, competition, and predation) and recruitment, growth, natural mortality and availability to surveys.

6. Expand surveys beyond typical boundaries to include the shelf break and the northern Bering Sea to evaluate the fraction of the stocks that are not assessed by the shelf survey. This will become increasingly important as species distributions shift northward as the Bering Sea continues to warm.

7. Expand the collection of underway oceanographic data and marine mammal sighting during standard assessment surveys.

Crabs

1. Natural mortality (M) estimates. Estimates of M (obtained independently from models) are needed for all stocks (except Bristol Bay red king crab), with highest priority assigned to Tanner and snow crabs.

2. Improved stock assessment of non-target crab. Highest priority research tasks include: (1) alternative indices of abundance (and biomass) and fishing mortality are necessary for species for which standard surveys are inadequate, and (2) life history information (specifically, natural mortality, size at maturity, and other basic indicators of stock production) for non-target crab to allow application of Tier 5 or Tier 6 assessment criteria.

3. Conduct field studies to improve knowledge of growth increments and molting probabilities and the relationship between shell condition and age of Bering Sea Tanner and snow crabs.

4. Improve understanding of seasonal movements, stock structure, natural mortality and harvest rates of crabs through mark recapture studies with emphasis on snow and Tanner crab stocks. In addition, improved understanding of seasonal movements of species without surveys or with a short time series of existing survey data are needed to assess the probability of incidental capture in other fisheries.

5. Improve understanding of processes influencing the fertilization rate of egg clutches, including consideration of spatial dynamics of crab reproduction and contribution to reproduction by males as a function of size, time post molt, and their distribution during stock assessment surveys and

during the fisheries. Primary emphasis is on snow and Tanner crabs, with secondary emphasis on red king crab.

6. Develop a spatial stock assessment model for eastern Bering Sea Tanner crab.

7. Conduct studies to improve crab aging using radiometric aging or lipofuscin and, for Bering Sea Tanner and snow crabs, improve knowledge of the relationship between shell condition and age.

8. Improve understanding of processes controlling recruitment dynamics for all FMP crab species. Incorporate these processes into scenarios regarding temporal trends in recruitment. Perform a management strategy evaluation using variable recruitment scenarios. This is a very broad topic encompassing the need to identify and assess biological and environmental effects on egg production, egg hatching, and larval survival, as well as mechanisms controlling the abundance of juvenile crabs from settlement to recruitment into the fishery. Factors include larval transport, predation, competition, and habitat availability. Effects of ocean acidification on crab larval growth and survival is also of interest. Primary emphasis is on stocks currently declared overfished: eastern Bering Sea Tanner crab, St. Matthew Island blue king crab, eastern Bering Sea snow crab, and Pribilof Islands blue king crab.

9. As an extension to research items 4 and 7, develop a spawning index which is demonstrably proportional to total fertilized egg production and be responsive to fishing mortality that could be used in stock-recruitment models for biological reference points determination for major red king snow, and Tanner crab stocks.

10. Examine the temporal dynamic of size at maturity for eastern Bering Sea Tanner crab and its implications on spawning biomass and fisheries management through analysis of the trawl survey data.

11. Conduct calibration studies to assess survey selectivity and catchability of snow crab, Tanner crab, and blue king crab with current trawl survey gear and new survey net.

12. Research on handling mortality rates. Better estimates of pot handling mortality rates by crab species are needed to estimate more accurately total bycatch mortality for all discarded species.

13. Describe Tanner crab habitat characteristics using side-scanning and/or multi-beam sonar to allow increased precision of survey catch rate estimates.

Scallops

1. Development of an age-structured model for assessment of abundance to be applied to each stock (e.g., Yakutat, Prince William Sound, Cook Inlet, and so forth).

2. Identify larval sources, as well as advective pathways, to evaluate the potential effects of fishing on recruitment for major beds.

3. Estimate survival rates for discarded scallops and of scallops contacted by the dredge that are not captured. [SSC modified with ADF&G Shellfish Priorities]

4. Investigate causes of high natural mortality recently observed in the Cook Inlet fishery, and scallop meat quality issues (i.e. off-color meats, 'weak meats', 'weak shell syndrome') observed in the Yakutat area.

5. Expansion of the recently developed remote video survey method for four objectives:

    a. to estimate densities and abundance of scallops in major fishing areas as well as in nearby unfished areas for monitoring environmental effects independent of fishing,

    b. to estimate catchability coefficients for commercial and research dredges,

    c. to evaluate habitat and distribution of non-scallop species that are present in scallop beds, and

    d. to conduct field studies to compare the dredge survey used in Central Region to the video sled survey.

6. Develop/standardize scallop shell aging methodology and complete aging of backlogged observer-collected scallop shells.

B. <u>Fishery Performance and Monitoring</u>
   1. <u>Improved onboard observations.</u> Improvements in at-sea observations are needed in several areas:
      a. <u>Observer deployment and coverage</u>. There is a long-standing need to review the allocation of observers among fisheries to adequately characterize the total catch, as well as a review of sampling procedures (e.g., basket versus whole haul) employed by observers that form the basis for total catch estimation.
      b. <u>Conduct research on mechanisms to supplement observer program information</u>. Improved means of data collection are needed, especially on small vessels. Research is needed on utility of other data collection methods, such as at-sea video monitoring, port sampling, and other direct methods.
      c. <u>Improved biological data collection</u>. There are needs to improve biological data collection (e.g., age, size, sex) of some bycatch species (e.g., sharks, skates, octopus, squid, sculpins, grenadiers) to better quantify potential effects of bycatch on these stocks. Better estimates of stock of origin are needed for salmon bycatch.
   2. <u>Improved estimation methods for total catch (including bycatch) and fishing mortality of all target and non-target species</u>. This may include revised observer deployment, use of flow scales, etc. Two levels of improvements are needed:
      a. <u>Improved estimation at the stock and fishery level.</u> Assessment and management depend critically on catch estimates. More rigorous statistical methods for catch estimation need to be implemented (e.g., Miller 2005). Specifically, identifying sources of variability in actual and estimated bycatch rates is needed. Approaches to integrate estimates of variance on the observed portion of the fisheries into the total catch estimates are needed.
      b. <u>Improved detailed estimation of catch for specific management programs.</u> Some management programs (e.g., IFQ, cooperatives, other rationalization programs) require extensive record keeping to increasingly finer degrees of resolution (e.g., vessel, subareas). Research is needed to evaluate the effectiveness of reporting systems to newly developed management groups or practices.

C. <u>Fishery Management</u>
   1. Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels using Tier 5 and 6 approaches for rockfishes and other poorly assessed species (e.g., squid, octopus, skates, non-target crab), as appropriate.
   2. Continue to develop a systematic approach to lumping and splitting that takes into account both biological and management considerations.
   3. Advancing ecosystem approach to fisheries management. This includes development of suitable indicators and indicator species (including novel approaches such as using corticosterone levels in predators as an indicator of prey availability, developing ecosystem reference points, including OY cap considerations, and improvements of current ecosystem models.
   4. Development of forecasting tools that incorporate ecosystem indicators into single or multi-species stock assessments to conduct management strategy evaluations under differing assumptions regarding climate and market demands. Standardization of "future scenarios" will help to promote comparability of model outputs. Process-oriented research focused on local impacts of fishing on prey availability for top trophic level consumers will also be informative.

5. Development of spatially explicit stock assessments that allow for management to be linked appropriately to stock boundaries and habitat use.

II. Fisheries Interactions

A. Bycatch

1. <u>Improved estimation of total bycatch including tier 2 marine mammals and seabirds.</u> At present, it is clear that observer coverage in some fisheries is insufficient for estimation of total bycatch. Examples include the sablefish longline fishery, skate fishery, Pacific cod pot and longline fishery, and halibut longline fishery. Improved accuracy of identifications and enumerations of bycatch species is necessary. The current program results in imprecise bycatch estimates for species, such as skates, sharks, yelloweye rockfish, and sablefish in halibut fisheries. Improved methods may include direct and alternative monitoring options (e.g., electronic logbooks, video monitoring) on smaller groundfish and halibut vessesls.

2. <u>Research on discard and handling mortality rates.</u> Better estimates of discard mortality rates by gear and fishery is needed to estimate more accurately total bycatch mortality for all discarded species, with an emphasis on such species as crabs, skates, sharks, rays, and octopus.

3. <u>Efficacy of bycatch mitigation measures.</u> Research is needed on the efficacy of bycatch mitigation measures (e.g., PSCs, time/area closures) and their effects on populations of the bycatch and target species, effects of changes in abundance of bycatch species on bycatch rates, and methods for assessing the economic and social costs of bycatch.

4. <u>Gear technology.</u> Further research is needed on gear modifications and fishing practices for reducing bycatch, such as research that has been conducted to protect salmon, halibut, rockfish and seabirds.

B. <u>Expanded Ecosystem Studies</u>

1. <u>Forage fish.</u> Understanding the dynamics of important pelagic and benthic forage species, such as capelin, herring, myctophids, euphausiids, shrimp, squid, and juvenile pollock remains a high priority for understanding energy flow to commercially important species and to protected species, including seabirds and mammals. Innovative approaches to assessing such stocks are needed and may include novel acoustic techniques (e.g. low-frequency sound), air-borne surveys, and indices based on the diet of predators, including seabirds or marine mammals.

2. <u>Ecological effects of bycatch and discards</u>. Selective removal of certain species of certain size ranges can affect the relative abundance of fish communities, perhaps with consequences on their ecological interactions. Moreover, fishery discards can favor scavenging species over others, perhaps with consequences on groups, such as seabirds and benthic communities.

3. <u>Climate change and fish communities.</u> Changes in ocean temperature and acidity may affect managed species and lower trophic levels. For instance, if recent changes in ice cover and temperatures in the Bering Sea persist, they may have profound effects on marine communities. Apparent declines in zooplankton wet weight over the shelf measured by the Oshoro Maru could imply the loss of critical copepod and euphausiid prey of important species, such as pollock. Existing data sets (bottom trawl surveys, BASIS surveys) can be used to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands and other areas of the Gulf of Alaska.

4. <u>Ecosystem structure studies.</u> Studies are needed the implications on food web interactions of global warming, ocean acidification, and selective fishing. For instance, studies are needed to

fully evaluate selective removal of some components of the ecosystem (e.g., Pacific cod, pollock) relative to others (e.g., arrowtooth flounder).

5. Ocean acidification and effects on marine ecosystems. As atmospheric greenhouse gas emissions increase, more CO_2 is absorbed by the sea surface, thus increasing levels of carbonic acid, resulting in lower pH. If trends continue, the ability of organisms, such as pteropods and king crab larvae, to form exoskeletons will be compromised, perhaps resulting in extirpation of these species. Monitoring of pH levels and additional studies of these effects are necessary.

6. Environmental effects on recruitment and growth. Studies on effects of climate on recruitment and growth (GPT C1) could include the development of standard environmental scenarios for future variability based on observed patterns. There is also a clear need for information that covers a wider range of seasons than presently available.

7. Nutrients and lower trophic levels. There is limited information regarding nutrient dynamics and phytoplankton/zooplankton dynamics on the Bering Sea and Gulf of Alaska shelves and through the Aleutian Island passes (e.g., supply of nutrients to the shelf, interannual variability and changes in nutrient supply, potential for HABs, etc.). Recent advances in technology such as towed undulating vehicles with various sensors and plankton recorders allow high-frequency sampling of both nutrients and plankton. Such sampling could support detailed process studies as well as the development of relatively low-cost monitoring programs in conjunction with existing surveys or through new surveys.

8. Predator-prey interactions. Diet information from seasons in addition to summer is needed to assess seasonal changes in predator-prey interactions. The diet information should be collected on the appropriate spatial scales for key predators and prey to determine how food webs may be changing.

9. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals and seabirds).

10. Relationships between oceanographic conditions, prey, and effects on scallop population health and distribution with an emphasis on Yakutat. Sporadic poor quality of scallop meats from the Yakutat area is an issue. A broader issue is the relationship between ocean currents and scallop metapopulation structure.

C. Protected Species Interactions

1. Population dynamics, life history and assessment of protected species including Steller sea lions, northern fur seals, spectacled eider, short-tailed albatross.

2. Local fishery interaction studies. Whereas global fishery control rules may generally prevent overfishing on a broad regional basis, non-random patterns of fishing may cause high rates of removals in local areas important to apex predators such as Steller sea lions and northern fur seals, spectacled eider, short-tailed albatross. More studies are needed to fully evaluate potential local effects of fishing on other components of the ecosystem (e.g., marine mammals and seabirds).

3. Economic, social, and cultural valuation research (i.e., non-market consumptive use, passive use, non-consumptive use).

III. Habitat

A. <u>Habitat Mapping</u>

　　1. Improved habitat maps are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming living substrates.

　　2. Improved identification and quantification of removal of species are needed in the broad "coral" category by the Fishery Observer Program.

　　3. Improved mapping of critical habitats are needed for listed marine mammals and seabirds, such as short-tailed albatross, spectacled eider, and Steller sea lions.

B. <u>Habitat Models</u>

Further development of habitat-based models of distribution, abundance, and sensitivities are necessary. Such models have great potential to lead to improved estimates of stock size and their spatial structure, as well as areas of sensitivity to fishing impacts.

C. <u>Effects of Fishing on Bottom Habitats</u>

Additional field studies are needed on the effects of fishing on seafloor habitats. Studies need to be conducted in a variety of bottom habitat types using a variety of gear types. Studies should focus on short- and long-term effects on benthic communities and bio-geological processes. Such studies are particularly needed in the northern Bering Sea.

D. <u>Management Strategy Evaluations</u>

Evaluate the effectiveness of existing closures to meet stated management objectives.

IV. Other Areas of Research Necessary for Management Purposes

A. <u>Social and Economic Research</u>

The need for the development and continued maintenance of basic social and economic information databases on the fisheries and fisheries dependent communities of GOA and BSAI is made ever more pressing as the Council continues to adopt actions that are intended to improve the long term net benefits derived from fisheries. This information is required for establishing a baseline to be used in identifying stakeholders to be included in the distribution of dedicated access privileges (e.g., harvesting quotas and processing quotas), a baseline to be used for projecting the likely consequences of alternative management measures, and as a baseline for retrospective analysis of management actions that have been taken.

<u>Particularly pressing research needs include:</u>

1. Development of an ongoing database of product inventories (and trade volume and prices) for principal shellfish, groundfish, and salmon harvested by US fisheries in the North Pacific and Eastern Bering Sea.

2. Analyses of current determinants of exvessel, wholesale, international, and retail demands for principal seafood products from the GOA and BSAI;

3. Pre- and post-implementation studies of the benefits and costs, and distribution of benefits and costs associated with changes in management regimes (e.g., changes in product markets, characteristics of quota share markets, changes in distribution of ownership, changes in crew compensation, as a consequence of the introduction of dedicated access privileges in the halibut/sablefish, pollock, and crab fisheries). "Benefits and costs" include both economic and social dimensions.

4. Prospective analyses of the robustness and resilience of alternative management strategies under varying environmental and ecological conditions; and,

5. Prospective and retrospective analyses of changes in the spatial and temporal distribution of fishing effort in response to management actions (e.g., time/area closures, marine reserves, bycatch restrictions, co-ops, IFQs).

6. Kodiak is at the center of controversy associated with the recently adopted crab rationalization program. What were the direct and indirect impacts and how were the impacts distributed throughout the community? As Kodiak is also likely to be at the center of controversy over the likely consequences of Gulf rationalization, it would be particularly advantageous if research could be designed to use Kodiak or other Gulf communities as case studies in analyses of the effects.

7. Develop a framework for collection of economic information on commercial, recreational, charter fishing, and fish processing to meet the requirements of this MSFCMA sections 303(a)(5, 9, 13), 303(b)(6), and 303A.

<u>Additional important research needs include:</u>

1. Development of longitudinal data sets of:
   a. Transaction level observations of exvessel, wholesale, and retail prices;
   b. Daily or weekly, firm-scale data on production by species and product form;
   c. Trip-scale data on variable costs (e.g., fuel, labor, supplies, etc.) for catcher vessels, catcher-processors, and sportfishing charters (this data should be matched with existing data on catch, catch composition, and production);
   d. Daily or weekly plant-scale data on variable processing costs (e.g., fuel and power, labor, supplies, packaging, etc.) for shore-based and floating processors;
   e. Annual vessel- or plant-level data on fixed costs (e.g., capital replacement, maintenance, repair, upgrades, insurance, etc.);
   f. Trip-scale information about the location and duration of fishing (e.g., VMS records, or observer information on steaming time, fishing time, etc.);
   g. Weekly or monthly data on patterns (location and magnitude) of expenditures associated with harvesting, processing, and sportfishing charters;
   h. Pay-period scale, vessel- and plant-level data on employment and income of fishery participants, especially crew and processing plant workers;
   i. Socioeconomic and demographic data for fishery dependent communities (income levels and distributions, population levels and distributions); and,
   j. Community- and regional-scale annual data on the distribution and magnitude of tax receipts and transfer payments associated with commercial and sport fishing.

2. Analyses or the development of models to evaluate:
   a. The evolution of community social and economic structure in response to alternative management actions:
      i) Baseline assessments of selected communities and industry sectors relative to social considerations identified by the Council and the Advisory Panel;
      ii) Field studies to elucidate the full array of linkages between fisheries and social and economic life in fishery dependent communities;
      iii) Regional economic models of activities and impacts associated with commercial, sport and subsistence fisheries;

      iv)   Prospective and retrospective studies of the social and economic impacts of alternative management actions;

      v)   Development of better methods for determining the social costs and benefits of management actions (e.g. through the use of non-market valuation techniques);

b.   The benefits, costs, and the distribution of benefits and costs associated with consumptive and non-consumptive uses of resources supported by the North Pacific and Eastern Bering Sea ecosystems:

      i)   Cost functions for harvesting, processing, and sportfishing charters;

      ii)   Producers and consumers surpluses associated with commercial fisheries under current and alternative management regimes;

      iii)   The magnitude and distribution of benefits and costs associated with sport and subsistence harvests under current and alternative management regimes;

      iv)   Existence and option values associated with corals, seabirds, and marine mammals;

      v)   The value of ecosystem services;

c.   Evaluation of alternative management strategies:

      i)   The cumulative efficiency and equity consequences of management actions that apply time/area closures;

      ii)   Management strategies and optimal yield for multi-use fisheries, e.g., commercial, sport, and subsistence fisheries for halibut and salmon;

      iii)   The relationship between sampling strategies and the confidence of bycatch estimates associated with individual and pooled bycatch quotas and the economic and social costs of bycatch;

      iv)   Changes in catch efficiency and operating costs associated with gear modification and avoidance behaviors intended to reduce bycatch;

d.   Evolving seafood markets:

      i)   Mechanisms for providing and costs of traceability systems for certifying product and production process attributes of seafoods;

      ii)   Consumer demand for seafood ands its associated byproducts harvested from stocks that have been certified as sustainably managed.